LIFE AND SCIENCE

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WITH INTRODUCTION BY
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PREFACE BY SIR OLIVER LODGE

In Professor Fraser Harris, M.D., D.Sc., we welcome one more Biologist who is able to make Science understanded of the people, and who has the gift of writing both accurately and popularly. He has inaugurated his return to this side of the Atlantic by publishing Life and Science, a book full of curious facts—some familiar, some uncommon, but all instructive and interesting.

The Author has already shown himself to be one of those who have the gift of using their specific knowledge for widespread edification and instruction. He is by no means only a specialist; his range is wide, and his acquaintance with science generally enables him to find numberless illustrations wherewith to illuminate his popular writings. Nor is he limited to the material side of things. He takes a wide scope,

and, though apparently of strict scientific orthodoxy, does not hesitate to survey mentally quite other fields, where the footing is less secure but the interest wider and more human.

The psycho-physical aspect of things has come into prominence; and the influence of the mind on the body, as well as the long-recognised influence of the body on the mind, has become a recognised and almost orthodox part of Therapeutics.

All this is fully recognised by Dr. Fraser Harris. But he leads up to it through the chapters in his book, and gives incidentally a great deal of information, which, though much of it is more or less familiar to most people, is here conveniently collected together and set forth in a systematic and trustworthy manner. For instance, one of the chapters is on sleep, why and how we sleep, what it is that happens to the functions of the body during sleep, why sleep is necessary, and what is the effect of withholding it, curious experiments which have been made both on human beings and on animals, and the kind of

mental condition in which sleep becomes impossible.

"Responsibility, worry, and grief must come to all at some time or another during life, else the life they are living is not life at all, but a soulless, bloodless simulacrum. As long as we 'walk through the valley of the shadow of death,' times must come of tears and sighs and sleepless eyes —but merciful fatigue is never far distant, and therefore, if it is true (as we have been so often told) that sleep *is* the image of death, then there is certainly for each one of us every morning a glorious protoplasmic resurrection."

Another chapter is on the trance state, or more generally on what the Author calls *latent life,* the kind of conditions under which vitality continues at a low ebb and in a state which it would be difficult to discriminate from actual death. The remarkable retention of life by the lower animals and vegetation is emphasized.

"Fruits—apples and pears—pulled off the tree and kept for some time are still alive; in fact they are still breathing,

that is taking in oxygen and giving out carbon dioxide; they are not dead, they are not even in latent life. They are not dead because, for one thing, they are not putrefying, and, in fact, their tissues and ferments are still too active to permit of their being described as in latent life. They are, as everyone knows, ripening, and this consists in their ferments forming sugar out of non-sweet materials. By being chilled, however, fruits can be brought into latent life, which is evidently the condition to have them in if storage for a long time is desired."

Another chapter deals with the rhythms of life, such as the heart beating, the vibrations of cilia in the bronchial tubes, the remarkable vibratory and apparently effortless quivering of a fly's wing. A bee's wing seems to make 190 vibrations in a second, a house-fly 330; while a dragon-fly is only about 28.

Perhaps the most important chapter in the book is the one on Nerves and Nervousness, where the vital and constant importance of nerve control in every func-

tion of the body is brought into prominence, and how the brain or central nervous system may be regarded mainly as an inhibiting or controlling organ. Remove this control either surgically or by hypnosis or otherwise, and the body will do all kinds of weird things. When the head is cut off a worm, the posterior part wriggles more actively than the head end : it has lost the automatic restraint of the head. If that is so, even in a worm, it is clear that inhibition and control is the most important part of education.

Then comes the chapter on the influence of the mind and faith and other psychic influences (which has been already referred to), and the curious electrical tests to distinguish real from pretended emotion, and indeed in another connexion to distinguish life from death. But apart from such tests, it seems true that—" faith can ' remove mountains '—mountains of physical disease and of mental disease, of misery and of suffering. And ' faith can subdue kingdoms,' the kingdoms of the rule of everything that is unlovely, such as

indifference to the welfare of others, self-seeking at the expense of others, and self-righteousness with the condemnation of others."

But apart from these medical and surgical results—on which, whatever the Author's competence, the present writer is quite incompetent to speak—the interaction between body and mind is demonstrated over and over again by a multitude of phenomena. And the old attempts at explanation such as epiphenomenalism and psycho-physical parallelism glaringly break down. Whether there can ever be an ultimate unification of the psychical and the physical must remain a problem for philosophers. But that the two are equally real and interacting entities has become absolutely certain. Neither can be subordinated or expressed in terms of the other. For scientific purposes they exist and they interact. Whether they always and necessarily interact, or whether they can exist separately, is a matter on which opinions may differ, and on which the Author of this book expresses no opinion.

He may, I suppose, be called a Vitalist; but his Vitalism seems to be quite an orthodox and non-revolutionary kind.

I may express a hope that before long more of his writings will be published and become better known. His book will help to make science widely understood, for he has the gift of writing both accurately and popularly.

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CHAPTER I

LIVING MECHANISMS BEFORE INVENTIONS

WHEN Denis Papin in 1681 devised his "steam digester" he probably thought he was *inventing* a process for resolving meat or bones into a much more soluble or digested condition. But what Papin had contrived to do by aid of superheated steam, or steam under pressure, Nature was doing daily in his own stomach when the meat of his dinner was being resolved into soluble substances (peptones) through agencies no more drastic than a temperature of 98° Fahrenheit and the activity of a little ferment called pepsin. A dog's stomach digests the bones of its meal more perfectly than does Papin's digester in much less time and with less expenditure of energy.

Possibly we think we discovered the principle, simple as it is, that is utilized in the clothes-brush or in the old-fashioned carpet switch; but for countless generations Nature has been using this principle in the cilia lining the mucous membrane of the organs of breathing. These little protoplasmic whips are in reality living brushes which continually sweep the mucus with its dust and germs down the nose and up from the lungs towards the mouth to be got rid of. They lash backwards and forwards at about ten times a second, and all the time need no conscious or other form of nerve control whatever.

Doubtless man thinks he invented the hypodermic syringe, but ages before that little instrument existed Nature had provided the snakes with sharp hollow fangs through which the poison gland forced the venom by muscular compression of the gland. Charles Gabriel Pravaz did indeed in 1851 invent the hypodermic needle and piston, but the principle it worked on was as old as the fossil snakes.

It is quite surprising how many con-

trivances now used by man to effect certain mechanical or chemical ends had existed in animal bodies for æons and æons before *homo sapiens* appeared on this planet. It would seem as though his latest inventions for utilizing the forces of Nature or for overcoming the limits of time and space were merely more or less clever imitations of mechanisms already in existence for countless ages in living bodies.

To take his very latest triumph—the flying machine; it is, of course, the mechanical bird, although the earliest attempts at flying failed because they imitated the wings of birds too closely. A man does not possess a muscle sufficiently powerful to actuate a wing attached to his body after the fashion of the wing muscles of birds. The pectoral muscles of man are relatively far too feeble to cause an artificial wing fastened to his body to raise it off the earth. But once he discovered a source of energy adequate to raising his weight into the air, the essence of the problem of flying was solved. The flying of a non-living mechanism is now an accomplished

feat, but Nature had her living flying machines for untold ages before man's aeroplanes flew.

To take another example; man has only the other day contrived to travel in a totally submersible boat. He uses the principle of gas in varying states of compression to cause his subaqueous vessel to rise or sink, but this is precisely the principle employed by Nature in the mechanism of the swim-bladder of the fish. This bladder contains gas secreted into it from the blood, and there can be no question that the fish's buoyancy is related to the volume and pressure of the gas in this sac. Increase of volume of the gas increases the fish's buoyancy, a decrease reduces it. Doubtless man did not consciously imitate the fish in constructing the submarine, but he unconsciously struck upon the same principle of flotation.

Again, consider the phonograph or talking machine, for its name in plain English really describes it better than the more pompous Greek. What, exactly, has man contrived to do in this case? The answer

is, to make a metallic or other membrane speak. This he has done by causing the membrane or diaphragm to vibrate in a manner wholly similar to that in which his own vocal cords vibrate when they initiate the process which ends in speaking. Aerial vibrations, emitted at a particular pitch, of a particular intensity and of a certain wave-form, constitute the essence of speech, and it is just because the phonograph can emit vibrations having these characters that it also can speak. Nature's membrane vibrated many millennia before Edison's.

In the telephone too, or that which "talks at a distance," the mechanism is again that of a vibrating membrane. No doubt the telephone is an electrically actuated membrane, but it vibrates, and that is all that the vocal cords really do. The analogies between the vocal apparatus and a wind instrument are very close. The vocal cords are the vibrating reeds, the trachea is the organ-pipe, the diaphragm is the bellows which, rising and falling, drives the air out of and sucks air into the wind-chest, the thorax.

Before we leave the non-living speaking mechanisms we might note that the principle of resonance is utilized in them as well as in the living body. The character and volume of our voice depend on the resonance by the air in the chest and back of the throat and in a number of other cavities in the bones of the head and face. The sound as produced by the vocal cords alone would be of a feeble, squeaking character, but when resonated by the air in the chest it is reinforced to such an extent that it becomes quite powerful and may acquire its characteristic quality.

Now man has been able to employ this very principle of resonance in order to make his talking machines talk with something like human volume and quality. The wood of the case in which the phonograph is placed, as well as the trumpet or mouthpiece with which the earlier instruments were always provided, acts as a resonator to intensify the sound of the membrane of the sound-box. The human larynx is a reed instrument. In one of the reed pipes of the great organ man has contrived

to imitate the capabilities of the larynx so well that the pipe has been called the *vox humana*.

The next form of energy we might study is that of light. We think that *we* have discovered for the first time in the world's history how to make of opaque materials that almost indispensable substance, glass, which is transparent to light. But ages before mankind fused opaque materials to make glass, living Nature possessed two tissues, the cornea and the crystalline lens, both of them as transparent as the finest glass. The curious thing is that the cornea when viewed under the microscope is seen to be composed of tissue elements very similar to those which compose the skin or the tough, coarse "white" of the eye, and both cornea and lens *do* become opaque after death. The cornea is literally the window of the eye, the only transparent portion in its otherwise absolutely opaque coats.

The eye, from the optical point of view, is an instrument of exactly the same type as the photographic camera. The

camera has a double convex lens to form a real, small, inverted image of external objects on a sensitive plate placed at a comparatively short distance behind the lens. The camera is blackened inside. The eye has a double convex lens which forms a real, small, inverted image of external objects upon a sensitive tissue, the retina, placed a short distance behind the lens. The eye also is blackened inside.

But this is not all. When the photographer wishes to sharpen the image on his ground-glass plate, he puts in front of the lens what he calls "stops," diaphragms with circular apertures of varying sizes, the smallest of which gives the sharpest image. This he does because the lens possesses what physicists call "aberration of sphericity," which means that the edges of the image are blurred. Now in the eye there is exactly the same mechanism, namely, that of the iris, a circular curtain with a central circular aperture—the pupil—capable of having its size altered by nerves and muscles according

to the amount of light falling on the eye. The pupil is small in bright, and large in feeble light. The lens of the eye also has spherical aberration. The iris of the eye, as a circular curtain capable of being closed or opened concentrically and with perfect symmetry of action, has been consciously copied in the diaphragm of the microscope. Here it is actually called an "iris diaphragm." It is found below the stage and above the condenser in a modern microscope. The analogies between eye and camera could hardly be closer. Lens, stop, sensitive plate, internal blackening to prevent internal reflections are all present in both the camera and the eye.

Doubtless no man consciously copied the construction of the eye when devising the photographic camera or the camera obscura, but it is exceedingly remarkable that when man came to make an optical instrument to form an image of the outer world, it should be found to correspond so closely to the construction of the eye, a living instrument designed for the very same purpose. These two—camera and

eye—have one thing more in common, that of being able to adjust the focus of objects at different distances. In the camera this is managed by altering the distance between lens and plate, in the eye by the lens bulging forwards to become thicker at its centre and therefore a lens of shorter focus, which is exactly what is required. In old age, by diminished elasticity of the lens, near objects cannot be focused at the same short distance at which they could in early life: this defect is called presbyopia or the sight of old people.

The next form of energy we may consider is electricity. It needs no prolonged dissertation to point out the multitude of uses to which this form of energy is now put. We use it for lighting, heating and power, for communicating at a distance, we use it in curative medicine and in a thousand other ways. Few of us realize that all these applications of electricity to our daily wants, and indeed our knowledge of the first principles of the science, arose out of a controversy at the end of

the eighteenth century between two Italians, Galvani and Volta, as to the reality of *animal* electricity itself.

Galvani, believing correctly in the existence of animal electricity and being criticized by Volta, who showed that certain cases of supposed electricity of animal sources were metallic in origin, devised many ingenious experiments to demonstrate electricity as arising in living tissues alone. Since his time electric currents have been found also in plant-tissues. It is now known that concomitantly with every activity of living protoplasm an electric current is generated, or at least a difference of potential between two related points is established. These "action-currents" are not difficult to demonstrate in muscle where electricity is one of the manifestations of kinetic energy, the other two being heat and external work.

In a nerve-fibre the electric disturbance is practically the only detectable manifestation of energy. The nerve-fibre acts pre-eminently as a conductor of nerve impulses, but these impulses as travelling

in the conductor can be revealed only through their electrical counterparts. No doubt the voltage of these action-currents in nerve is very small, but they are none the less electrical. The most striking example of electricity of animal origin is, of course, in the electric fishes, creatures which produce currents sufficiently powerful to kill their prey. It has been estimated that the most powerful of these discharges of electricity by fishes reaches an intensity of 200 volts. Æons and æons, then, before man discovered electricity and its adaptability to his numerous wants, Nature had been producing this same form of energy in her invisible living batteries. It has often been remarked, for example, how much the cross section of a submarine cable resembles that of a large nerve trunk. The nerve fibres are in fact Nature's living conductors or wires, and the one is insulated from the other in a manner wholly analogous to that of wires in a cable.

Turning now to mechanisms that are more purely physical, let us notice the simplest of these, the nail. Presumably

man discovered at an early period of his history the simple and useful device of the nail or rivet for holding two pieces of board or metal together. In the living body the same device is used to fasten down the membrane covering the bone to the bone below. These fibres or living nails are known as "the perforating fibres of Sharpey" and are of fibrous tissue so calcified as to be literally "as hard as nails." Living nails also fasten the nourishing membrane of the tooth to the tooth itself.

Another familiar device of the carpenter is dovetailing, as he calls it, or cutting the opposite edges of two boards in such a manner that they are made to interlock, and so cannot be pulled apart except by great violence. Nature uses this device in the so-called "serrated suture" or line of union of two flat bones, as in the flat bones of the cranium. The interlocking of the margins of the bones is so perfect that only by enormous force can they be separated, and then only by the complete destruction of the dovetailing.

There is scarcely a more familiar mechanism than that of the hinge. The hinge joint is a well-known type of joint in the body, the elbow, wrist, knee, ankle and many others being all hinge joints. An equally familiar mechanism of human construction is the swivel or universal joint. The shoulder joint and the thigh joint are examples of swivel or ball-and-socket joints, so that Nature apparently did not feel constrained to confine herself to one type of bony articulation. The joint that "locks" and so prevents over-action is seen in the knee and elbow joints; in fact, the stork can go to sleep on one leg and not tumble over, largely because its knee joint locks so securely.

The next device we might notice, one used from remote antiquity, is that of the arch with its keystone. Bridges of this kind made by the Romans exist all over Europe. Now anatomists tell us that the plantar arch of the instep is precisely such an arch. It has a front and a back pier which support an arch of such immense strength, very largely because it

is constructed on the keystone principle. The pulley is a machine which one instinctively associates with human contriving, but the pulley was in use in the animal body ages before a pulley was ever made by men's hands. A pulley is essentially a device for altering the direction of action of a force. Pulleys are used in the animal body to enable a muscle which is not in the same straight line with its attachment to pull as though it were. The muscle is in one direction, the tendon in another, but by the tendon going over a pulley the muscle can literally pull round a corner. One of the muscles of the eye has this arrangement, also one of the muscles of the middle ear and several muscles of the foot. Of course the more complicated orders of pulley, where there are many sheaves in the block, are not found in the body: Nature attains her ends by the simplest means possible.

When, however, we come to levers we find that all the types of lever are used in animal mechanisms. In the first order of lever the fulcrum is between the power and the

weight or resistance; in the second order the fulcrum is at the end of the lever beyond the resistance; in the third order the fulcrum is also at the end of the lever but is next the power. These, then, are the only possible orders of lever, and examples of all are found in the bodies of animals.

We use a lever of the first order when we nod the head; the fulcrum is at the joint between the head and spinal column, the weight of the head acts through the floor of the mouth, and the power is exerted by the deep muscles of the neck which pull on the back of the head. The relative arrangement of weight, fulcrum, and power is exactly as in the see-saw; when one child goes up the other goes down, so with the head; when the chin falls, the back of the head rises and *vice versa*. This first order is the lever of mechanical advantage. The way in which the foot is used to work the pedal of a harmonium or a sewing-machine is also an example of a lever of the first order. A pair of scissors is a double lever of this order.

The lever of the second order is used in the body when we stand on tiptoe. Here the fulcrum is the "balls" of the toes, the weight of the body passes through the plantar arch, and the power of the great hamstring muscles acts upwards from the heel bone. The whole body is raised by a group of its muscles. If the weight of the body be 150 lb., then the calf muscles only exert a pull of about 90 lb. to raise the body off the ground. This lever is the lever of power. The oar of a rowing boat acts as a lever of the second order, for the fulcrum is in the water, the weight is the boat, and the rower applies the power at the end of the oar. Nut-crackers and lemon-squeezers are examples of double levers of this order.

The lever of the third order is employed in a great many instances in the animal body. When we raise the hand towards the head we use it. The fulcrum is the elbow joint, the weight is the hand and anything it may contain, the power is applied by the biceps acting on the fore-arm beyond the fulcrum. This is the

lever of rapidity of action; we use it when we wish to execute some action with maximum speed. When with extended arm and hand grasping a racquet, we bring the arm swiftly forward to strike the ball, we use a lever of the third order; the effort expended is great, but what we lose in power we gain in speed. To raise one pound in the hand, we have to put forth an effort corresponding to 4 lb. near the elbow-joint. The sugar tongs is a double lever of the third order.

Related to the mechanisms of joints and muscles we might notice the catch-and-let-go mechanism which man has made use of. All instances of forces pent up, restrained, caught back, and then suddenly let go are cases of this. It is the trigger mechanism; the coiled spring caught back and then let go to eject the harmless bullet of the child's pop-gun is an instance of it, the spring of Jack-in-the-box is another. Nature uses this catch-and-let-go or flicking mechanism every time a cheese maggot catches its tail by the front end of its body and then, suddenly

straightening itself, lets go and leaps forward. These maggots have been photographed before, during, and after their flight. Every time we want to flick a paper pellet away from us or get rid of a piece of fluff on a coat we use this device. The bent finger, as is well known, is held back by the thumb, but all the time under strong muscular action. After an instant or two we release the finger suddenly, and it strikes the object we have in view far more forcibly than it could if merely extended without previous resistance.

It is when we come to valves in the body that we find man perhaps most completely forestalled.

We all know how absolutely indispensable are valves of one kind or another to the efficient working of the steam-engine and many other mechanical inventions. A valve is essentially a contrivance for permitting a flow of liquid or gas in one direction but not in the opposite. Water-pumps, air-pumps, and all machines which work on those principles depend entirely on the efficiency of their valves. The

simplest type of valve is that found in the veins where two pouches opposite each other at certain intervals are so placed that the blood going to the heart can pass easily in that direction, but cannot reverse its stream because the attempt to do so closes the valves behind.

Much more complicated are the valves in the interior of the heart where the flaps or cusps have special cords to keep the free borders from being forced too far back. The mechanism consists in the shortening of certain muscles inside the ventricles, and is comparable with that of a compensating pendulum whereby a movement in one direction is counteracted by an equal amount of movement in the opposite direction. Thus while blood can pass quite easily from auricle to ventricle, none of it can go in the opposite direction owing to the fact that in attempting to do so it closes the valves or doors behind it. At no fewer than four distinct places in the heart has Nature used this valvular mechanism, so anxious is she to permit a flow of blood only in one, the forward, direction.

The valves in the lymphatic vessels are exactly like those in veins. The mechanism of the valve is used for purposes other than preventing a back flow of blood or of lymph. It is used between the great and the small intestine to prevent the reflux of material from the one to the other. The valve in this case is a lipped valve with oblique entry. A similar valve is used in the bladder to prevent the ascent of urine from the bladder into the ureter, the duct of the kidney, whence it has descended. There is an analogous valvular arrangement in the larynx which prevents the escape of air from the chest when it is necessary to maintain an air-cushion in the chest in order to make very vigorous muscular exertions.

Hardly any machine is commoner than the pump, whether it be the force-pump or the suction-pump. Now the heart is alternately first the one and then the other. The ventricles of the heart are a force-pump when they are driving the blood out into the arteries; they are a suction-pump when they are dilating and sucking blood in from

the veins close to them. More technically put, in the latter case they create a negative pressure in their interior with the result that the blood flows into them from the body veins where it is under a greater pressure. Negative pressure is utilized in a large number of machines of human contriving. Nature employs negative pressure in the organs of breathing in the following way: when it is necessary to get air into the lungs, the walls of the chest rise somewhat rapidly, with the result that the air inside the lungs is rarified, a negative pressure is created and therefore outside air at atmospheric pressure at once flows into the lungs. Gases always move from places of higher to those of lower pressure. Of course the converse mechanism, that of creating in the lungs for a short time a pressure greater than the atmospheric, causes the impure air to leave the lungs.

Allied to the employment of negative pressure in animal mechanisms there is the principle of the boy's "sucker." This is a disk of leather which is pressed down

on to a wet, smooth paving-stone on which it will slide about quite easily, but from which it cannot be pulled up by its string without considerable force. If the stone is loose, it can sometimes be lifted bodily up. The explanation is that a negative pressure has been created under the leather disk, so that it is pressed against the wet stone by the weight of the atmosphere. This principle is employed to keep the outer surface of the lung and the inner surface of the chest wall in contact and yet permit perfect sliding movements between them.

The property of elasticity is of very great value in modern mechanical contrivances, but living bodies possessed elastic tissue untold ages before mankind discovered the numerous uses of indiarubber. Indiarubber, though the product of a living tree, is not itself alive. The elasticity of the coats of the arteries makes the pulse possible; if the arteries were rigid tubes, the rhythmic dilatation we call the pulse would not be possible. In certain diseases the arteries do become stiffened, and un-

toward results follow from a diminution of elasticity.

In some machines the elasticity of the spiral spring is utilized. The living body has its spiral springs in the shape of spirally coiled arteries. When the tissues are relatively collapsed these spirals are wound up; when the tissues become turgid, full, expanded, then the arteries are to some extent unwound, which could not happen if they had been constructed as simple, straight tubes. Being spirally wound they can be pulled out exactly as we pull out a piece of spirally wound electric wire. This device is used in the pregnant uterus.

The principle of the spring is used in quite another kind of manner, as, for instance, in the ligament which holds open the two halves or valves of an oyster shell. To close the shell the oyster uses a muscle (the adductor), so that when this muscle loses tone and dies the shell must of necessity lie open, since the spring of the ligament is not now antagonized by muscular action. In mechanisms of human devising this principle is employed in such

cases as a spring to hold a door shut; we open the door by our muscular effort. The opposite of this is inextensibility or extreme toughness. When we tie two things together with rope or with straps we do not want the ropes to stretch or "give." Living Nature frequently utilizes the same principle when she unites two bones by a ligament, or a muscle to a bone by a tendon. These bands of tissue must not be capable of being stretched. They must hold the bones together, not rigidly but without any yielding or stretching when movements are carried out by the bones. Ligaments entirely fulfil such conditions, for they are excessively tough and quite inextensible.

Animal elasticity is present in muscle for exactly the same reason that we find a spring interposed between the traces and the carriage, namely, to prevent a jar to the horse when he suddenly attempts to pull the carriage forward. When we contract our muscles suddenly, as we often need to, there would be an uncomfortable jar sent to the bones, were not the muscle

possessed of some elasticity or "give." There is some "give" in the traces before the horse starts the carriage, and exactly the same mechanism is provided for by the presence of elasticity in muscles. But further, a healthy muscle is always tight or "taut" as sailors call it. The result of this is that the moment the muscle gets from its nerve the command to shorten, it is able to do so with the least possible delay. If the muscle were at all slack there would be time lost in pulling in the slack, but owing to the constant tightness this never occurs.

Even the idea of the inextensible outer cover over an inner tube is not something that mankind hit upon for the first time in the history of the universe. The distensible heart is covered by a tough, inelastic cover, the pericardium. Were it not for this tough cover the heart would easily and frequently be over-distended. The heart answers to the inner tube, the pericardium to the tough outer tyre.

In most mechanical contrivances we wish friction reduced to a minimum; in

a few we want some amount of friction retained. The animal body has examples of both these things. The surfaces of the cartilages clothing the ends of bones in apposition at a joint are not only exquisitely smooth but moistened by a liquid which, containing a good deal of mucus, is as good a lubricant as oil. Nature uses this synovial fluid exactly where engineers use oil to reduce friction at bearings, etc.; and when in disease this liquid dries up, then the joints creak and grate exactly like the hinges of a door in need of oiling.

Sometimes the opposite effect is desired. For instance, when the chemist wants to grind up some very slimy or slippery material with his pestle and mortar, he throws in some clean sand or powdered glass in order to make the pestle catch or grip the substance to be crushed. Here he desires friction, and it is supplied by the gritty particles of the sand. But ages before the chemist hit on this, Nature had arranged that certain birds should retain stones in their gizzards or muscular sto-

machs in order that the smooth grains should be able to be grasped by the very smooth, horny walls of the gizzard, and so be ground up as finely as possible.

We have thus seen how remarkably mankind has been forestalled in the matter of the principles utilized in a large number of machines; transparent tissues, lenses, iris diaphragms, optical images, photo-sensitive surfaces, pulleys, levers, valves, pumps, the use of negative pressure, elasticity, coiled springs, buoyancy, and electric energy were all in use in animal bodies millions and millions of ages before man himself appeared on this planet. When in the fullness of time he did appear and laboriously learned to construct machines to do work for him, he was merely discovering principles but not inventing them. The devices had been in existence for countless millennia before he thought and worked, so that in this sense indeed there is nothing new under the sun.

CHAPTER II

HOW WE DEFEND OURSELVES FROM OUR FOES

In the last chapter we considered certain mechanisms with which Nature has endowed living beings to enable them to carry out their several vital activities; in the present chapter we are to meditate on the contrivances whereby those animals can defend themselves from their ever-present foes.

For in a certain sense even now, in the midst of his civilized communities, mankind is waging ceaseless warfare against a number of hostile conditions, both animate and inanimate. Serious as this is now, it must have been much more acute in the earlier times of the race.

Man had to defend himself, as best he could, from the great cosmic exhibitions

of energy—the extremes of heat and cold, the tempest, the lightning, the avalanche, the earthquake, and the tidal wave. Primitive man, we are assured, must have lived in the midst of alarms of all sorts and in the constant dread of attacks by fierce animals far more powerful than himself. Undoubtedly he sought shelter from wind, rain, snow, and frost in those caverns in which his skeleton and the bones of the animals he slew for food and fur are yet to be found.

In many parts of the world he built his wooden huts on piles out from the shore of some lake, so that he had his food supply in the fish under the floor, and was also more secure against the wild animals when his dwelling had to be defended only on one side instead of on four.

The latent powers of his nervous system permitted him to develop that speed of running in flight whereby he saved himself from the avalanche, the tidal wave, or the beasts of the field. Not alone was speed necessary, but also rapidity of response on the part of his nervous system

in order to take warning from the impending danger: that man lived longest who most rapidly reacted to the danger signal, stepped most agilely out of the way of the rolling boulder, skipped most briskly aside from the infuriated lion or bear. Of course, as we know, he early devised his weapons of offence and fired his flint-tipped arrows at the animals threatening his life or destined to be his store of food for a long time to come. That man throve best who most accurately threw his stone or javelin, so that quickness of response (short "reaction-time") and accuracy of aim—both powers of the nervous system—were early in the history of our race the means of escape from enemies or the mode of procuring a sufficiency of food.

The first human line of defence is, then, nervous or mental; our ancestors established themselves on the earth by means of such powers of the nervous system as speed, accuracy, and co-ordination of movements; and these are of supreme importance even yet. He who jumps quickest aside from the runaway horse escapes

with his life; the old gentleman, whose reaction-time age has lengthened, who does not step aside from the carelessly driven motor-car sufficiently perfectly, gets run over. Those men who after harpooning the whale got their boat most quickly out of the reach of his tail were most likely to reach the big ship in safety. He burns his fingers least who most rapidly drops the hot coal.

While, nowadays, shortness of reaction-time may only occasionally contribute to the actual saving of life, yet it does assuredly contribute towards what is called "success" in life. He who most quickly grasps a situation of danger and acts accordingly has an advantage over his neighbour with the more sluggishly reacting nervous system. It is obviously by his development of intelligence—a power of the nervous system—that man has not only conquered nature, animate and inanimate, but has learned to use its forces, even the most hostile, in the interests of his own comfort and prosperity. Our first line of defence is, then, mental; and the

elements of time and precision are all-important.

We have, however, to reckon with foes far more subtle and more often met with than the thunderbolt, the lion, the bear, or the electric eel. In some parts of the world, the living things that can poison us are very numerous; venomous snakes, scorpions, countless insects, are all ready to pour their poisons or acids into our skins. Mankind has learned that alkali will neutralize their acid, and has in these latter days discovered how to manufacture an *antivenin* to counteract the venin or venom of the serpents.

We fight chemical injuries by chemical means. But all these sources of danger or injury are insignificant compared with those which are absolutely and for ever beyond the ken of our senses. In common with all other living things, we are surrounded by parasites and preyed upon by them continually. It seems a law of animate nature that any given living thing, vegetable or animal, should have its particular parasite or parasites. For even the

vegetables have parasites: the potato has the potato-blight, a fungus; the vine has its phylloxera, another kind of fungus, and so on. The lower plants prey on the higher, the higher on the highest. Fungi and moulds are parasites on both plants and animals. Animals are parasitic on plants: grubs eat the roots and the buds of flowers, the aphides destroy the roses, the Colorado beetle devours the potato. The gooseberry moth strips the leaves off the gooseberry plant; the oak has its galls, everything its blemishes.

To such an extent is all this recognized nowadays that a department of botany called economic vegetable parasitology has arisen within the last few years. Expert botanists are studying the conditions under which these pests appear and therefore how we may either guard our flowers and food-vegetables from their ravages, or remove the parasites when once they have settled on their victims. The loss to farmers, fruit-growers, and horticulturists each year through parasites is enormous. Fungi and moulds are parasitic on animals as well

as on vegetables; the salmon has the fungoid salmon disease, the grouse has the bacterial grouse disease, the barn-door fowl has its cholera, the swine have swine-fever, the cattle have anthrax and rinderpest, horses "glanders," and so on.

Then animal parasites infest animals; the frog's lung harbours certain lowly creatures known as Gregarinidæ; dogs, cats, pigs, horses, all have their intestinal parasites, from which obnoxious worms man himself is by no means exempt. Host and unbidden guest, victim and parasite—this inter-relationship runs through the whole of living nature; it is not the exception, it is the rule. Nature has indeed provided for it; the intestinal worms of the horse have actually developed an *anti*-ferment which prevents their being digested by the digestive ferments of the horse's intestine. Attack and defence, action and reaction unceasingly, this is Nature's method; there is no rest, and there is no splendid isolation; we must be attacked and preyed upon and resist—for ever! A few plants and animals

have taken refuge in "protective mimicry"; the dead-nettle imitates its stinging neighbour, and so is avoided by such animals as avoid the latter; some insects imitate dead leaves, twigs, etc., and so are not devoured by insect-eating birds.

But the majority of the foes that man has to battle with are far more subtle than intestinal worms or mosquitoes, or even fungi; for there are myriads of bacteria so light that they float in air even when dust settles; so small that millions can inhabit a drop of water; so numerous that arithmetic is powerless to compute them; so powerful that they have emptied cities, decimated armies and devastated continents. The mortality of the Boer War had been a trifling thing if the English had had only to reckon with the Mauser bullets; far more deadly were the typhoid bacilli than all the guns of all the Dutchmen and their allies.

It is now common knowledge that nine out of ten diseases have an actual, physical, recognizable source or cause in some particular parasitic bacillus (rod-like form)

or coccus (round form). Undoubtedly some diseases are due to microscopic animal forms, such as ague (malaria), yellow fever, dysentery, the sleeping sickness; but the vast majority are due to vegetable parasites of microscopic size. All those serious diseases known as diphtheria, typhoid fever, cholera, plague, tuberculosis, pneumonia, influenza, rheumatism, common cold, and infantile paralysis, have been shown to be due to the living body being invaded by countless numbers of infinitely minute rod-like or ball-like microbes.

No doubt not all bacteria are disease-bringing (pathogenic); and it is well for us that it is so, for the air, earth, and water teem with bacteria of some sort. Many are quite harmless, and are occupied only with getting rid of dead bodies by putrefactive fermentation.

But our present concern is with our invisible foes, and we must now try to find out how our bodies protect themselves against their presence and their poisonings. We have three chief methods whereby we defend ourselves from our invisible foes—

namely, the physical, the vital or protoplasmic, and the chemical.

We possess an outermost line of defence in the intact skin and the mucous membranes, the horny layer (keratin) of the skin and the mucus-covered layer on the internal surfaces being impenetrable by micro-organisms.

The living colony—the entire animal—is surrounded by armour, the body is armour-plated, the keratin of the skin is the armour-plating. Once a rift occurs in the armour, a crack, a split, a crevice, an abrasion, a cut, or a puncture, it matters not which, then the entrance of our foes is a possibility, nay, a probability. These rifts need not, of course, be perceptible to the naked eye, they may be barely discernible under the microscope, but they are large enough to admit bacilli, and that is all that is needed ; diminished resistance within the citadel ensures its conquest. The outer surface of the teeth, the enamel, the hardest tissue known, is indeed not able to be directly attacked by bacteria, but they force an entrance just underneath

it and undermine it so that it is easily broken in.

When what is called a foreign body—bullet, fragment of metal, etc.—has gained access to the organism and cannot be removed by cellular absorption, it is very often walled off or encysted, as it is termed. Pathologists who make post-mortem examinations tell us that from time to time they come across instances of old growths often calcified (stony), so covered up by inert tissue as to wall them off from the surrounding structures and so keep them from doing any further harm.

Another physical means of defence is wetness; the wet mucous membranes of nose, throat, and lungs retain the dust and bacteria which stick to them. Bacteria wetted are bacteria imprisoned; it is only when dry that they can be wafted about on their disease-bringing errands.

But the mucous membranes of the nose, throat, and lungs are covered with cilia.

When we mention cilia, we pass to the second or vital means of defence. Cilia, as we saw in the last chapter, are whip-

like prolongations of the cells lining the breathing passages, and they are continually lashing the mucus in which they are immersed with its dust towards the mouth and nostrils. In this way the bacteria caught in the mucus are removed from the body, and thus it is that mucus containing disease-germs should be burned and not allowed to dry and so set free its burden of bacteria. In prolonged bronchitis these cilia are known to be absent from the bronchial mucous membrane, thus depriving it of a valuable mode of defending itself from micro-organic invasion.

The chief vital agents concerned in fighting our invisible foes are the white cells or leucocytes of the blood. These minute living things are apparently exceedingly sensitive to the presence or the secretions of micro-organisms, for they come out of the blood capillaries shortly after the bacteria have invaded the neighbouring tissues. Their mode of attack is frontal; they literally fall upon the intruders and, swallowing them bodily, digest them, so rendering them powerless for any further

activity. If the bacteria do not prove very poisonous, the phagocytes are not killed; if, however, the poison (toxin) of the bacteria is a virulent one, the leucocytes are killed and their dead bodies constitute "pus" as surgeons call it, or "matter" as other people call it. In suitable preparations for the microscope it is possible to see large numbers of microbes in a semi-dissolved state inside the white cells. One kind of leucocyte paralyzes or kills the microbes without engulfing them. Of course leucocytes will do their work well or ill according as they themselves are in good or bad health, vigorous or enfeebled. All exhilarating conditions tend to invigorate the leucocytes, all depressing conditions to enfeeble them. The leucocytes are, then, the second line of defence—the rank and file of the defending army. When once the outermost physical barriers have been penetrated by the enemy, these living agents take up the defence by active, offensive measures.

The third mode of defence which we

possess is the power of our body-cells to manufacture certain chemical substances having the property of neutralizing the poisons of the bacteria which have invaded us. All the body-cells co-operate more or less vigorously in this the most subtle method of dealing with the soluble toxins manufactured by the bacteria multiplying in the blood or other body-fluids of the unwilling host.

These soluble toxins affect, stimulate, the tissues of the victim, which, being living cells, react, and the expression of their reaction is the outpouring of a chemical something, appropriately called an antitoxin, which, uniting with the bacterial toxin, neutralizes it and prevents it exercising its injurious powers. The infected organism thus works out its own chemical salvation by a vital, but no less chemical, response to the poison of the infection. To do this efficiently is to recover, to fail to do so is to remain infected, to be injured chemically, possibly to die. This production of antitoxin on the part of the infected body is a vital, pro-

tective mechanism of a chemical order; it is the chemical reply to a chemical insult. If the attacked body-cells can provide sufficient of this antitoxin to neutralize *all* the toxin made by the bacteria, the individual will not merely get well, but will remain immune from that particular infection for a long time, because when once the body-cells begin making antitoxin they make a great deal more than is needed to neutralize all the toxin which the invaders have manufactured.

Hence it is that a person who has successfully come through some infectious disease, smallpox or scarlatina, for instance, cannot, for some time thereafter, be reinfected with the poison of that disease; his blood contains an *excess* of the antitoxin of that disease so that any toxin of that kind happening to be produced within him is immediately neutralized. He is immune from or refractory to this infection for a certain time, it may be years. He has fought a good fight microchemically, and his tissues now rest from their labours.

Man has taken advantage of this natural

chemical immunity to confer an artificial immunity on himself. When a person gets over an attack of diphtheria, it is because his body-cells, stimulated by the poison of diphtheria (diphtheritin), produced sufficient anti-diphtheritin to neutralize the poison; but it is clear that if he can get anti-diphtheritin ready made, the diphtheritin in his body will be neutralized all the quicker. Mankind makes use of the horse. A horse which has recovered from an attack of diphtheria and thus has in his blood plenty of anti-diphtheritin (specific antitoxin) has some of his blood drawn off. If a little of this blood, specially treated, be injected into the person suffering from diphtheria, the person will recover, or if it be injected into a person about to be subjected to the infection of the disease, that person will not take the disease. This is conferred immunity; it has been conferred on man by the horse's blood-serum.

Thus we have three kinds of immunity from infection:

I. An original, congenital refractori-

ness towards the disease which may be called *natural* immunity ;

II. *Actively acquired* immunity, the ordinary condition of having come successfully through an infectious illness.

III. Artificially or *passively acquired* immunity, or conferred immunity, one of the latest triumphs of biological science.

All these varieties are chemical means of defence.

Coming under the head of chemical means of defence, we have the existence of an acid in the gastric juice. It is well known that when the acid (hydrochloric) is present in the stomach in the proper quantity, it is uncommon to be infected by micro-organisms through the alimentary canal. I knew of an officer who had come through a severe epidemic of cholera in the West Indies, and who, on being asked if he had been afraid, said : " I had no fear as long as I knew that my digestion was not out of order." We and the other mammals are not the only animals whose

alimentary canals are guarded by a free acid; there has been discovered in the Mediterranean a mollusc (*Dolium Galea*) whose gastric juice contains sulphuric acid. This free gastric acid is distinctly antiseptic.

We have now disposed in a certain fashion of our modes of defence against foes from without; but it is unfortunately as true in a physical sense as it is in a moral that a man's foes are those of his own household. We are liable to chemical assaults from within, whether from poisons secreted by the bacteria inhabiting our internal organs or from poisons arising from the imperfect digestion of our food. Food may have poison in it at the time it is taken, the so-called "ptomaines"; but poisons may be developed in it in consequence of its not undergoing its digestion in a perfectly healthy fashion. Many such digestive poisons are dealt with by the liver. The liver is a very large gland placed in such a position that all the blood coming from the organs of food-absorption must pass through it on the way to the heart.

The liver deals as best it can with the poison reaching it from the intestine; in some cases, retaining it for a time, it eliminates it in an altered form; in other cases it renders it innocuous and permits it to reach the circulation whence it is removed by the kidneys. This power of the liver is known as its *de*-toxicating power. In this way is explained the well-known condition of being poisoned when the liver is "out of order." When the liver is not doing its *de*-toxicating work sufficiently well, not trapping poisons, these pass on into the blood-stream and affect the whole body; the headache and the malaise being the result in consciousness of this general chemical poisoning. Deranged digestion, then, is responsible for the production of the poisons of auto-intoxication which the liver should seize and render harmless.

The chemical defences of some people are so feeble that they are always on the verge of just not being protected from the poisons of their own intestines, so that such persons are hardly ever free from

headache. Other people suffer from periodical outbursts of poisoning associated with one-sided headache (megrim or migraine). Some of the sufferers from this form of headache have been amongst the most distinguished persons in science and literature, for Haller, Emil du Bois Reymond, George Eliot, and Sir James Simpson were all victims of this distressing condition.

CHAPTER III

ON CERTAIN VITAL RHYTHMS

Thus far we have studied vital mechanisms and vital defences, the latter closely related to the great subject of the influence of the environment on the organism; in the present chapter we have to consider certain activities in life which seem to a large extent to be independent of the environment.

A phenomenon which may be called rhythmic is one that recurs at equal intervals of time or at any rate not at cognizably unequal ones. The dripping of water from a leaky tap is rhythmic, but the murmur of the brook is not. The universe is full of rhythms. The succession of the seasons, the alternation of day and night, the phases of the moon, the ebb and flow of the tide, the recurrence of spring and neap tides, the yearly rise

of the Nile, the November flight of meteors, and so forth, are all examples of cosmic rhythms. The magnitude of the time interval or period of the rhythm is not of the essence of rhythmicality. Thus, the behaviour of the æther in transmitting light-waves is rhythmic, the frequency being only some billionths of a second; whereas the return of a comet such as Halley's to our solar system, although a matter of seventy years or so, is just as rhythmical; its reappearance is periodic.

Music is essentially rhythmic; in fact, it is the periodic character of the vibrations of the air that constitutes music as opposed to noise. The vibrations of the air objectively constituting noise are highly irregular or arhythmic. A clap of thunder is not rhythmical. In a rhythm something recurs at equal intervals of time; if this something recurs at unequal intervals, the rhythm sometimes is spoken of as irregular. This usage would make the word "rhythm" synonymous with regular rhythm, which is the general acceptation and the one in which the term will be used

in what follows. It is owing to the regularity of recurrence of eclipses, the equinox, meteors, comets, etc., that these phenomena can be predicted with an accuracy that makes astronomy as an exact science so justly admired. The periodicities of rhythms in the non-living world may be matters of years, months, weeks, days, hours, minutes, seconds or fractions of a second.

Coming now to the realm of Life, we find rhythms pervading everything. The plants, with striking regularity, have their own times each year for putting forth the buds, unfolding the leaves, bursting into flower, and finally allowing all the perfumed beauty of the flower to fade in order that the fruit shall be formed as a life in death. Thus the poetess sang:

> Leaves have their times to fall,
> And flowers to wither at the north wind's breath;
> Thou hast all seasons for thine own, O Death!

In plain prose, there is no rhythm about Death.

"Chestnut Sunday" is approximately the same Sunday, and "Apple Blossom"

week practically the same week each year. The opening and closing of flowers is rhythmic, the rhythm depending on the waxing and waning of the intensity of daylight.

Doubtless the most familiar rhythms are in the world of animal life. Here we have rhythmic actions of animals as gathered into flocks and herds, of animals as individuals, and of the organs, tissues, and cells of the animal body. The migration of birds is annual in rhythm. It is only part of the truth to tell us that the waning light and diminished heat and food are what constrain the birds to leave us: they know *when* to leave us. Migratory birds which have spent all their lives well-fed in the captivity of Regent's Park, nevertheless become restless at the approach of autumn. Again, those animals which hibernate during the winter know when to betake themselves to their hiding-places whence they come not forth until the spring.

The rhythm of the sexual activities of birds is one of the most characteristic

things about their behaviour. It is only in the spring that the " livelier iris changes on the burnished dove," but it is *every* spring. Even a brainless (decerebrated) pigeon will " coo " energetically at the breeding season, although if the hen bird be placed near him he will take no notice of her. The sexual rhythm is inherent in the lower parts of the nervous system, but in the absence of the brain it is a meaningless and mechanical rhythm.

Practically all the activities of one's daily life are rhythmic, the most obvious perhaps being the regular alternation of waking and sleeping. There is a well-marked rhythm in our digestive organs, in the organs of excretion, and most pronouncedly in the beating heart. Rhythm pervades the world of animal life: just watch that transparent jellyfish in the limpid summer sea, and you will notice how the edges of the umbrella contract or pulsate with slow and regular rhythm (about 30 in the minute). Equally obvious rhythms are those of the wings of birds and other flying things; of the legs in walking and

dancing; of fins in swimming. Large birds fly with slow, leisurely rhythm, small birds with a fast one; just as tall men have a slow stride, short men a more rapid step. Regular rhythms are everywhere; if Nature ahbors a vacuum, she also abhors fits and starts: living Nature does everything "decently and in order."

The periodicity of the heart's action is an excellent example of a rhythm of animal origin. Seventy-two times in a minute this wonderful hollow muscle contracts (systole) on the contained blood, forcing it out into all the arteries of the body, and seventy-two times in the minute does it dilate (diastole) and suck blood in from the veins leading to it. The duration of its cycle is therefore eight-tenths of a second (60/72), and in health during the many years of a long life it practically does not vary from this value. If, for more than a few seconds, the heart's rhythm becomes distinctly irregular, then we conclude that something is amiss with this wonderful organ within our breast.

Sometimes we come across a heart with

a congenitally fast rhythm, a condition called tachycardia, and sometimes one with an abnormally slow rhythm, a condition called bradycardia. Whereas the rhythm of the heart-beat is for each individual a certain average rate, it varies in different individuals according to height and age. Thus, tall persons have slower hearts than short people; and infants have a heart-rate about twice as fast as adults. The whale and the elephant have very much slower heart-beats than the mouse or the sparrow. The heart-beat in these small animals is so fast that the pulse cannot be counted in the usual way: until recently we had no reliable information about it; but by an electrical method used by a physiologist, Miss Buchanan, D.Sc., working at Oxford, it has been ascertained with great accuracy

The pulse-rate, which ought to be the same as the heart-rate, is very much slower in the cold-blooded than in the warm-blooded animals. Thus in a fish or frog the heart contracts only about forty times in a minute, or about half the mammalian

rate. This relatively slow rate can be quickened by making the heart beat in warm salt water, when the rate can be made to exceed that of the normal mammalian heart. A further study of the warm-blooded heart proves to be full of interest. It can be accelerated by warmth and slowed by cold; but it is its affectability by nerve impulses which is so remarkable. It is a matter of common knowledge that the heart can be made to beat much faster at one time and slower at another through nerve impulses alone. Everybody knows that emotions can influence the heart very markedly. Thus, of course, it has come about that the expression "the heart" is taken as synonymous with certain emotions. Some emotions "disturb it" in that they cause it to beat more rapidly, while some slow it and enfeeble it.

Now physiologists have discovered two distinct sets of nerves which influence the heart-rate; the one set on being stimulated makes the heart faster and stronger (accelerator and augmentor nerves), the other set on being stimulated makes the heart

beat more slowly or may stop it altogether (inhibitory nerves). Evidently the former set arouses the heart to greater activity, the latter set induces in it less activity than normal.

The rhythmicality of the heart is not conferred on it by the action of nerves or by the presence of blood or the temperature of the blood, or by any other "external" condition: its rhythmicality is inherent in it, is spontaneous (autogenic). The rhythm of the heart is of the essence of its life: the microscopic cells of the embryo heart beat with a rhythm as soon as they are perceptible at all, and long before nerves have reached them or even any blood has been formed. Spontaneous rhythmicality is the great mystery of life, the central puzzle in biology: if we knew what rhythm really was, understood it "all in all," we should "know what God and man is."

But heart is not the only rhythmic portion of the circulatory system. In all animals, portions of the large veins have the power of rhythmic contraction—in the bat sixteen times per minute—and in some

animals (frogs, for instance) there are pulsatile sacs or lymph-hearts, dilatations of the lymphatic vessels beating visibly under the skin of the back. Many other organs exhibit rhythms. The activity of the stomach is rhythmic, also that of the intestines over which waves of contraction pass at short intervals; the activities of the gall bladder, the urinary bladder, and the uterus are all rhythmic.

An interesting thing about rhythmic organs is their inability to have the rate of their rhythm forced beyond a certain limit. No amount of stimulation of the accelerator nerves can increase the rate of the heart-beat beyond a certain limit. Similarly, heating the heart will raise the rate of the rhythm, but only up to a particular figure which cannot be exceeded. Working with the pigeon, I found that the greatest number of beats per minute which the heart (auricle) could give was 300, or five a second; and beyond that it was not possible to force it. Not only, then, is rhythmicality inherent in the living substance of the heart (cardiomyo-

plasm), but also a power of resisting all influences to accelerate it beyond a certain limit, a kind of "functional inertia," as I have called it.

Let us now take another example of rhythmic activity as seen in the cilium. A cilium is a minute, whip-like process of living protoplasm projecting from the surface of the cell. There are millions of these cilia covering the mucous membrane of nose, throat, and bronchial tubes. Now, these cilia lash backwards and forwards at a characteristic rate of ten to twelve times in the second. Just as the heart makes 72 systoles and 72 diastoles in a minute, so the cilium bends forwards ten times and backwards ten times in a second, or six hundred times a minute, about eight times as fast as the heart. Otherwise put, the period of ciliary oscillation is one-tenth of a second instead of eight-tenths.

But the rhythmicality of the cilium is as inherent as that of the heart. The cilia receive no nerves, therefore not being innervated they cannot possess any rhythm conferred on them from outside by nerves

(neurogenic). The cilia are, however, easily influenced in their rate of vibration by changes of temperature and by drugs and poisons. By warming the cilia they lash faster and faster until they attain a speed of about twenty a second, beyond which they cannot go; one more example of a limit set. Conversely, cold and narcotics like chloroform slow and finally stop the action just as they do in the case of the heart.

We may now inquire into the rhythms exhibited by muscles and nerves; almost everybody knows that muscles act (contract or shorten) by having nerve-impulses sent into them either by the will or in an involuntary manner. Soldiers who were wounded in the late war soon came to be aware that if one of their great nerves was cut they had no longer any power to move certain muscles, which they learned to call "paralyzed." Now these nerves all come from the central nervous system, so that the impulses they transmit must also have their origin in that system. The nerve-cells which give rise to these nerves and nerve-impulses are called nerve-centres,

and it is these centres which emit impulses to the muscles in a definite rhythm.

Let us take the case of breathing. Normally an adult breathes about sixteen to eighteen times a minute—that is to say, in a wholly unconscious fashion his diaphragm—the great, curved muscle between the chest and the abdomen—descends eighteen times and rises eighteen times in the minute. There is, therefore, a respiratory rhythm just as there is a cardiac and a ciliary. Now, the diaphragm would not make any descents were it not that it was receiving nerve-impulses through its nerves (phrenics). After these nerves have been cut, the diaphragm is absolutely still. Clearly, then, the rhythm of the activity of the diaphragm is not inherent, but, on the contrary, is conferred by nerves or is neurogenic. The rhythm of eighteen to twenty a second must be the rhythm of discharge of nerve-impulses from the nerve-cells or centres from which the phrenic nerves come. It is the nerve-cells that have this rhythm, not the nerves as conductors and not the diaphragm as a muscle.

The actual cells from which the phrenic nerves proceed are, however, not the breathing centre, which, situated farther up in the central nervous system, commands the phrenic centres to issue their periodic discharges of nerve-impulses. It is the chief respiratory centre, therefore, that has the real respiratory rhythm, which, like the heart's, varies with age and other circumstances. We know very well that the rate of breathing can be profoundly altered by emotional states; some conditions, states of excitement, greatly increase the rate, others slow it or stop it for a time, as in the phrase, "it fairly took my breath away."

Experiments have shown that heated blood accelerates the breathing and cold slows it, and there are drugs which have analogous actions. Further, the will can for a time abolish the rhythm altogether. Divers are able intentionally to "hold their breath"; on the other hand the will, if we so wish it, can hurry up the rhythm beyond the rate of the normal. This faculty of having a rhythm which

can be altered by the will is quite a rare one amongst the centres of the nervous system. The normal respiratory rhythm is, then, an additional example of a rhythm inherent in something—in this case in the cells of a nerve-centre—but capable of responding to outside influences. And again, there are limits set, for neither by the will, nor by emotion, nor by heated blood, nor by drugs, can the rate of the breathing centre be forced beyond a certain maximum value. Breathing is to all intents and purposes an involuntary, unconscious activity: the diaphragm rises and falls throughout life, whether we wake or whether we sleep, with a regularity that is as constant and with efforts that are as untiring as those of the heart itself. In a word, the rhythm of breathing is not voluntary, although we can interfere with it voluntarily.

But, of course, the nervous system gives us plenty of examples of rhythms of voluntary origin. Take the very simple case of tapping one's finger on the table or on an electric key. I can tap my fore-

finger once a second, twice a second, three times a second, and so on, until I am tapping it so fast I can barely count it. When this rate is reached, an instrument of simple construction can prove that the finger is being flexed and extended at about ten to twelve times a second. We may note in passing that this is exactly the same as the ciliary rate. Now the instrument will show that beyond ten to twelve a second the ordinary person cannot go, although it is possible to train musical technicians to "trill" at a considerably greater rate than that of ordinary people. Still even for experts a limit is soon reached. The rhythm of the cells of the centres giving rise to the nerves to the fingers is evidently of this sort that whereas the cells can be made by the will to assume any slow rhythm from one to twelve a second, they cannot be forced beyond that limit.

What, then, is the rate of the inherent rhythm of these centres? Probably ten to twelve a second; although all physiologists are not agreed about this figure

and the point is one not suitable for discussion in the present essay. It is reasonable to suppose that these cells have a normal, natural, inherent rate of discharge which may be one and the same as their maximal rate. Neither by the will nor by artificial stimulation can this maximum be exceeded, not even when the rhythm of the artificial stimulation is much higher than twelve a second. The nerve-cells have physiological inertia towards rates of stimulation greater than that of their own maximal rhythm. The respiratory centre, on the contrary, we saw, had a normal rate which was *not* also its maximal.

Rhythm or intermittency pervades the nervous system. It has been ascertained that we cannot utter syllables (articulate) at a greater rate than ten to twelve a second. What we may call the articulation centre has its upper limit set at this same figure we have so frequently met with. The numerical identity of the rhythms of cilium, musculo-motor nerve-centre, and articulation centre is not merely accidental.

The periodicities of insects' muscles are

of the following orders: The wings of the dragon-fly vibrate at 28 a second, those of the wasp at 110, of the bee at 190, and of the house-fly at 330 per second. The late Professor Mosso aserted that the pitch of the note of a bee setting out on its day's rounds was perceptibly higher than that of the note heard at the close of the day.

It is probable that the receiving or sensory portions of the brain are constructed in such a manner that they, too, have limits in dealing with rhythmic or intermittent presentations.

The spokes of a slowly rotating bicycle wheel can be perceived as separate bright lines, but when the wheel is revolving rapidly the individual spokes fuse into one bright metallic surface, just as the separate slats of a paling viewed from an express train fuse into one continuous surface. The grooves of the milling on the edge of a metal disk spun rapidly under the finger are perceived as constituting a rough but continuous surface. The fusion of the members of a series of instantaneous photographs of moving objects presented

in very rapid succession to the eye, as in the kinematograph, is due to this incapacity of the brain to resolve as distinct in consciousness the separate components of the physical series. If the interval between the successive impressions is longer than about 1/40th–1/50th of a second we do not get fusion, but the well-known and disagreeable state of "flicker." These and many other cases prove that there are strict limits to the perception of rhythms by our brains.

The causes of vital rhythms and periodicities are virtually unknown. Physiologists can describe vital rhythmic actions in their own precise language, but that is all. To say that the cardiac cycle is constituted by the two alternating and opposite phases of katabolic systole and anabolic diastole does not bring us any nearer an understanding of the cardiac rhythm. Protoplasm in general tends to act intermittently. Just as a single tap given to a jelly or to a spring will make these oscillate or vibrate for some considerable time thereafter, so a single or continued

stimulus given to living matter will cause it to discharge energy in a vibratory or oscillatory manner.

Nor do we comprehend any better the significance of the particular time-duration of the interval between the recurring vital events. Why, for instance, should the heart beat 72 times a minute and not 7 or 700? Why should we breathe 18 times and not 8 or 80 times a minute? Why should the cilium bend 10 times a second as its normal rate and just twice as fast, but no more than that, when urged to do its utmost? These things are mysteries. The rhythms of functional activity in the female reproductive organs are familiar facts of physiology, but what induces the rhythm and why the periodicity should be as it is are problems at present entirely unsolved.

Probably the necessity of rest to prevent fatigue or exhaustion is one of the purposes of vital rhythms. The heart, for instance, can continue to beat so indefatigably just because the duration of its time of rest (diastole) in the cycle is longer than that

of its activity (systole). We sleep by night in order to be active by day. All work and no rest is a physiological outrage: rhythm is an expression of that physiological normality in which work alternating with rest is most economically performed.

It is the most familiar things in life that stand most in need of explanation. Rhythmic action is very familiar, but great is the mystery of rhythmicality. That the heart should exhibit its livingness by phasic activity, that the periodicity of these phases should be controlled by nerves and influenced by certain environmental conditions, are the very A, B, C of physiology, but they are also the alpha and the omega of physiological problems.

CHAPTER IV

SLEEP LIFE'S GREAT RHYTHM

In this chapter let us inquire into the causes of one of the most familiar rhythmic processes which we go through, namely sleep.

The phenomenon we call sleep is very interesting from more than one point of view. Were we so inclined, we might study sleep in the spheres of religion, philosophy, art, and poetry.

Probably no physiological condition is so prominently before the poets as sleep. "Death and his brother Sleep," as Shelley puts it, or "Sleep, Death's twin brother," as Tennyson has it. Shakespeare's lines are hackneyed only to those who do not believe that "a thing of beauty is a joy for ever":

> Sleep, O, gentle sleep,
> Nature's soft nurse ! how have I frighted thee !
> That thou no more wilt weigh my eyelids down
> And steep my senses in forgetfulness.

We might remind ourselves of the peculiar view that sleep is the normal and natural condition of mankind, while our waking states are a series of more or less disagreeable interruptions of a blissful unconsciousness. It is perfectly true that as regards the infant, its periods of wakefulness *are* of the nature of intrusions into its otherwise unbroken sleep.

But our study is the Physiology and Hygiene of Sleep; that is to say, we set ourselves to ask and answer the following questions: What is sleep as a state of brain? What is sleep as a state of mind? and what must we do to ensure the onset and continuance of healthy sleep? The first is a question of physiology, the second of psychology, the third of hygiene.

Now nothing is easier than to ask what is called "a simple question," but it does not by any means follow that a simple question can of necessity or at all times have a simple answer.

It does not follow that because sleep is so exceedingly familiar to us we have attained to complete understanding of all

its causal factors. For it does not necessarily follow that the recurring state which we so succinctly name "sleep" is itself the result of only one easily cognisable cause. In other words, we ought to be prepared to find that there may be more than one type of sleep just as there is more than one type of walking or swimming or talking.

And it is equally true that although we can describe sleep in technical terms, we need not thereby be much nearer a comprehension of its causal antecedents.

Normal, dreamless sleep is the resting-time of that part of the brain related to consciousness, but in proportion as dreaming is present the abolition of consciousness is incomplete.

Physiologically sleep is diminished or abolished activity of that part of the brain (cortex) related to consciousness; psychologically, it is rhythmically recurring periods of unconsciousness terminating in a spontaneous return of consciousness.

There is a rhythm or periodicity about the onset of sleep which is normal or healthy

—the basis of the "habit" of sleep so valuable to those possessing it, so difficult to reacquire by those who have lost it. On the speculative side we may connect this rhythm in the occurrence of sleep with those great cosmic and vital rhythms around us—the rising and setting of the sun, the ebb and flow of the tide, the opening and shutting of the flowers, the periodicity in the action of the heart and so forth.

Most animals with a nervous system rest at regular intervals even when they do not actually lose consciousness. The more lowly the nervous system of animals the less do they sleep: fish, for instance, never truly sleep. The brain—cortex cerebri—like so many other organs has a functional rhythm, it is not continuously in full activity; it works, it rests. When it works we are conscious, when it rests completely we are unconscious; a dream is, physically, the partial activity of an otherwise resting sensory or higher centre; psychically it is the arousing of the particular kind of consciousness related to the

centre or centres in question. Apparently in normal conditions the adult brain requires to rest some seven to eight hours out of the twenty-four. But a child of six, for instance, requires about thirteen hours' sleep. It is not now believed that women need less sleep than men.

We all know that a *state of healthy fatigue* precedes the onset of healthy sleep; and that, when in good health, we awake rested, refreshed, and fit once more for the labours of the new day. Fatigue, whatever it is, is removed during sleep and completely only during sleep. Now as a certain amount of fatigue is inevitable if physical or mental work is to be done, and as fatigue cannot be entirely removed except in sleep, it is at once clear that unless fatigue is to go from bad to worse, sleep is an absolute necessity. It has been fully proved that loss of sleep is a more serious condition to the body than loss of food.

In absence of food, the brain lives on the muscles, and rests periodically as usual; in loss of sleep, the brain never gets any

rest, and it is too delicate a mechanism to work continuously.

This is just the difference between a delicate non-living mechanism like a watch and the delicate living mechanism the brain—the former never becomes fatigued. Professor de Menacëine, of St. Petersburg, kept some puppies awake for five days, at the end of which time they died, although they were taking food; whereas the controls, which were allowed to sleep as much as they liked but from which food was entirely withheld, survived to the twentieth day and were saved by being cautiously fed. A sleepless animal at the end of three to four days is as miserable as a starved one at the end of ten to fifteen days. *Prolonged* sleeplessness in the human being damages the brain and nervous system most, but other grave bodily changes occur; the temperature becomes subnormal, the number of blood-corpuscles is diminished, the specific gravity of the blood is raised, the various reflexes are irregular and enfeebled. A certain amount of sleep, then, is equivalent to a certain

amount of food. People who sleep on past breakfast time are often not particularly hungry when they wake, and are quite willing to wait till lunch.

Science is a search for causes, so that we must in the next place try to discover what are the conditions that lead to sleep; if we knew these fully, we might be able to treat causes of insomnia on rational principles.

The first thing to ascertain is what are the variations during sleep from the normal waking state of the body. As everyone knows, the *muscles* pass into a state of diminished tone, they relax; but as the muscles and their antagonists relax simultaneously and to the same degree, no distortions of limbs are produced. The muscles which raise the upper eyelids having, however, no antagonist, on relaxing allow the lids to fall, and thus light is prevented from stimulating the retina. The muscles of the neck which hold the head erect also relax and allow the chin to fall forward on the chest, so that people "nod" ere they fall asleep. As

regards the circulatory system the heart beats less frequently and less strongly, the general blood-pressure falls, and the vessels of the skin are dilated, giving the flush to the "sleeping beauty." The respirations are shallower but rather more prolonged, less air and therefore less oxygen is absorbed, and less carbon dioxide evolved. In consequence of all this the production of animal heat is diminished and the temperature falls. Less urea is eliminated. All these facts point to one conclusion: that general metabolism is decreased in energy—that is, the tissues are to a certain extent resting.

The digestive apparatus and its glands are not, however, nearly so inactive as was at one time believed. The distinguished Russian physiologist, Pavlov, has proved by observations on the dog that digestion does go on. The late supper *is* digested; the dreams it may give rise to are due, not to its not being dealt with, but to the unusual muscular activity necessary to deal with it at the time when the stomach is usually inactive. The digestive glands

and the glands of the skin are now known to be secreting in sleep. Owing to the activity of the skin, a chill is easily taken during sleep, for as heat is being parted with through the skin, if the bed-clothes fall off or are insufficient, the loss of heat may be very considerable before consciousness is awakened to rectify matters. The loss of heat in sleep is of course the reason why, when persons have to sleep in the open air, or in rooms with widely open windows—the open-air cure—the body must be very thoroughly covered with non-conducting materials. The entire body is resting in sleep, but the central nervous system is resting most profoundly. It is, however, accessible to stimuli above a certain degree of intensity; if it were not we could never be wakened.

The sense-organs and brain are not absolutely but only relatively inaccessible to stimulation. Whereas a noise of a certain intensity will not, a louder noise will penetrate to the centre for hearing and may awake the sleeper. A sensory stimulus may not in all circumstances

wake the sleeper, but through the central nervous system it may arouse a series of reflex actions. Thus the sleeper spoken to may only move uneasily and readjust his position in bed or he may even say a few words. Using this knowledge, certain thieves in India manage to steal the mattress from underneath a sleeping person without wakening him. Motor actions of a fairly complicated kind can be carried out during sleep. As a result of a dream, a person may speak more or less coherently, and even walk a considerable distance—somnambulism. The barking or growling of dogs in sleep is undoubtedly the motor-overflow of a dream.

Acted dreams are due to overflowings of nerve-energy aroused by the dream-activity of certain sensory centres actuating lower-level centres for the carrying out of more or less complicated muscular co-ordinations with which consciousness has nothing whatever to do. What is said in sleep is not remembered, what is done in walking is not recalled. The somnambulist may tread in the most dangerous places and yet

maintain his balance; if wakened, he may lose it and injure himself severely.

Accessibility to stimulation is the basis of the methods for testing the depth or intensity of sleep.

As long ago as 1863, Kohlschütter made experiments, since corroborated, on the relationship between the intensity of a sound necessary to awaken a sleeper and the time that had elapsed since he fell asleep. A metal ball was allowed to descend from varying heights on to a metal surface and the results were plotted on a curve. Along the abscissa is time in half-hours, along the ordinates are heights from which the ball was dropped which awakened the sleeper. It is seen that at the end of the first hour the ball had to fall through 800 units, whereas at the end of two and a half hours it needed to fall through only 50 units to have the same effect. Sleep, therefore, during the first two hours or so is the most profound and therefore the most reparative and valuable. The fact that the first two hours of sleep are the soundest and most refresh-

ing is probably the foundation of the saying that one hour before midnight is worth several afterwards, and that that hour is the hour of the "beauty sleep."

Now, while it is instructive to analyze the state of normal, healthy, nocturnal sleep we must remember that it is allied to a number of states of brain all characterized by more or less complete abolition of consciousness.

These are:

1. The hypnotic trance, the cataleptic trance or artificially induced sleep; sleep by suggestion: related to this is the state of narcolepsy, lethargy, or human hibernation.

2. The unconsciousness occurring in syncope, fainting, collapse or exposure, conditions undoubtedly related to grave cerebral anæmia.

3. The unconsciousness occurring in concussion or shock.

4. True coma, the unconsciousness related to auto-toxæmic conditions —uræmia, glycohæmia, asphyxias, etc.

5. The more or less complete un-

consciousness (narcosis) resulting from the absorption of some narcotic—the bromides, chloroform, opium, alcohol, ether, chloral, sulphonal, and other "hypnotics."

We may now attack the central problem—"what are the causal factors involved in the production of sleep?"

It will simplify matters if I say that I believe there are four types of sleep related respectively to the following four conditions:

1. The presence of chemical substances.

2. A diminution of energy of the circulation.

3. The absence of sensations.

4. The absence of intellectual activities.

There is no manner of doubt that the chief causal antecedent of normal sleep is healthy fatigue. We cannot sleep if we are not tired, though we may be "too tired to sleep." Fatigue is now regarded as really a mild toxæmia, there being in the blood certain toxins or soluble poisons

manufactured by the activity of the tissues —both nervous and muscular—during the preceding period of wakefulness. The muscles, the nerve-centres, and the glands all make their contributions of fatigue-toxins. On the chemical or toxin "theory" of sleep, the chemical substances affect the *neural synapses*[1] in such a fashion as to raise the resistance at these junctions and so retard and then prevent the passage of nerve-impulses of ordinary intensity across them.

The actual *cause* of the raised resistance *may be the retraction* of the excessively delicate nerve-terminals at the synapses; but whatever be the precise mechanism, the resistance to all incoming (sensory) impulses is so raised that they fail to reach the sensory centres. Many well-known drugs and poisons, for instance, nicotine, morphine, atropine, probably act similarly by raising the synaptic resistance. This functional isolation of the cells of the

[1] A synapsis is the place of junction between one nerve-cell (neuron) and another. There are millions of these in the brain and nervous system.

brain related to consciousness is psychically the unconsciousness of sleep, always provided that certain cells are not kept partly awake by errant dream-producing impulses. Thus the chemical and the sensory factors both co-operate to bring about the sleepy state or "somnolence"; the fatigue-toxins raise the synaptic resistance to such a degree that the sensory impulses fail to reach the cerebral areas connected with consciousness; consciousness, therefore, for the time being vanishes. A large accumulation of fatigue-toxins produces sleep under almost all circumstances. There is no resisting the onset of chemically caused sleep. As has been said, "we suffocate our cells in the ashes of our waking fires."

Many of the camel-drivers in Kitchener's forced march to Khartoum fell from their seats in sheer exhaustion and *slept* there and then on the sand while the whole army corps thundered past. In the old coaching-days postilions often fell asleep on horseback and yet rode on in the saddle. One remembers that De Quincey's "Vision of

Sudden Death" was written after he had been driven at thirteen miles an hour by a driver fast asleep on a mail coach. Sentries have fallen asleep on their feet from utter exhaustion and have yet retained their balance. More than once the cross-channel swimmer, Holbein, has been noticed by the men in the boat to be swimming asleep. The neuromuscular toxins had poisoned and isolated the synapses in the brain but had not similarly disabled those of the spinal cord through which impulses for the co-ordinated reflex actions of unconscious swimming were still possible.

The spinal cord does not sleep, then, in the sense that the brain does; as it is not related to consciousness, so neither does it suffer in its reactions when consciousness is abolished. A Colonel of Volunteers, after having gone through twenty-two hours of extreme fatigue in connexion with the great Volunteer Review of 1881, walked in his sleep in the dark for several miles along a coast road towards his home.

A similar experience is related in Kip-

ling's *Stalky and Co.*—"after that, I went to sleep ; you can, you know, on the march when your legs get properly numbed. Mac swears we all marched into camp snoring, and dropped where we halted." In the great retreat from Mons—one of the glorious phases of the Great War—the exhausted soldiers would sometimes fall asleep just leaning up against a stone wall with their rifles in their hands.

Extreme sensory stimulation or the endurance of long-continued pain finally brings on sleep. In the "good old days" of torture, people used to fall asleep on the rack. A vivid instance of sleep after prolonged "bullying," physical and mental pain, is also given in *Stalkey and Co.* "When Fairbairn had attended to me for an hour or so, I used to go bung off to sleep on a form sometimes." Here the excessive activity of the cells of the sensory centres probably produces neural toxins which, by a kind of self-preservative mechanism, so raise the synaptic resistances that further impulses are debarred from gaining access to the centres which they would otherwise

keep awake. Physiologists have, of course, attempted to identify these sleep-producing substances in the blood. Preyer believed that lactic acid was largely responsible for somnolence; he thought it was oxidized off during the night.

Now it is quite well known that occasionally, in conditions of excessive fatigue, sleep is often impossible for many hours—we are too tired to sleep. Children more especially complain of this. Possibly here the insomnia is partly due to pain or discomfort arising from the over-exercised muscles, tendons, or ligaments, and partly due to the fatigue-toxins having actually an irritant instead of a narcotic effect on the sensory cells of the brain.

Acting normally in co-operation with fatigue-toxins the absence of sensory stimulation is a cause of sleep. Everybody knows that we get off to sleep best when we retire into the darkness and exclude the sounds of the outer world. Within limits, sensations keep us awake until they are of such duration as to produce fatigue—e.g. the constant rattle of the railway-

train in which, as soon as we are tired, we can sleep quite well. Sensations other than those through the eyes and ears can keep us awake—those of heat or cold or of pain are all efficacious. This sensory factor in sleep is, then, essentially a negative one, it is the absence of sensation that conduces to sleep, its presence to sleeplessness. Long-continued sensory impressions—"droning" reading or preaching—may permit of sleep by virtually ceasing to be sensations engaging consciousness. Any persistent not very vivid sensation—the contact of the air, our clothes, etc.—ceases in time to be for us a conscious perception at all.

Having once become accustomed to sleep, say, in the noise of a great city, the quiet of the country so arrests the attention that sleep for some people is at first not possible. For though this is physiologically the absence of sensation, yet it is psychologically the engaging of consciousness which is of itself sufficient to prevent sleep. Strictly speaking, this is a case of insomnia of psychic origin. The onset of sleep, as due to the withdrawal of sen-

sations, is strikingly shown in a case known as "Strümpell's boy." This was a boy of sixteen years of age living in Leipzig who suffered from the following sensory abnormalities—he was insensitive to touch, he had no sense of smell or taste, no muscular sense and no sense of pain (analgesia), he was deaf in the right ear and he was blind in the left eye. If his left ear was stopped up and his right eye bandaged, he fell sound asleep in two or three minutes. Persons whose sensory content is very limited, through rudimentary education, such as Russian peasants, fall asleep very easily.

We may now pass on to the *vascular factor* in the production of sleep. Most authorities have come to the conclusion that sleep cannot set in unless there is a diminution in the vigour of the cerebral circulation. Some of the earliest observations on sleeping persons and animals report a state of relative anæmia—that is, diminution of velocity of blood-flow, and therefore in unit time less blood passing through the vessels of the brain. Some

physiologists, while admitting that this diminution in the cerebral circulation occurs, hold that it is a concomitant of but not a cause of sleep. First, then, let us bring forward the evidence in regard to this vascular factor. Blumenbach in 1795 was the first to observe, through a wound of the skull, that the blood-supply to the brain was diminished in sleep. Arthur Durham in 1860 trephined a dog's skull and inserted a glass window into the hole. He noticed that the brain became paler when the animal was asleep. By ligature of the carotid arteries he produced a condition resembling sleep in which the brain was distinctly pale. Direct inspection of the exposed brain of sleeping animals has convinced Mosso and Tarchanoff that the surface of the brain has relatively less blood than in the waking state.

Now one result of there being less blood in the cranium during sleep is that the pressure of the cerebro-spinal fluid between the brain and the skull would be slightly less, and therefore that the dura mater[1]

[1] The tough covering of the brain substance.

would press less strongly on the cranial vault. Accordingly the anterior fontanelle in the infant, a membrane between the bones of its skull covered with skin, is seen to be depressed during sleep and elevated during wakefulness.

Tarchanoff has demonstrated that the only position in which puppies *cannot* go to sleep is that in which their heads are lower than the level of their bodies. Leonard Corning in America induced sleep in an acute maniac by compression of the carotid arteries. Interesting corroborative evidence as to the reduced energy of the cerebral circulation may be found in the observations of Hughlings Jackson on the retina of somnolent children. In every case he found the retina decidedly less vascular than in the full waking state; as sleep passed off the vessels of the eye filled up.

But we have still other evidence to prove that the blood-supply to the brain is diminished before and during sleep. The method consists in converting the skull into a plethysmograph, which is an instrument for recording the varying volume of a part

or organ. The infant skull by reason of the existence of the fontanelle is a natural plethysmograph for the brain; a tracing got from it falls in sleep. Mosso in 1881 applied a plethysmograph to wounds in the skulls of several patients and obtained similar results. It is very well known to surgeons that in fracture of the skull the cerebro-spinal fluid is greatly diminished in its flow or does not flow out at all during sleep.

We can make the arm or the hand tell the same story. If the arm be enclosed in a water plethysmograph, it is noticed that as sleep comes on the volume of the arm increases, when sleep passes off the volume of the arm diminishes. There is a reciprocal relationship between the intracranial and limb volumes, for undoubtedly if less blood is now in the brain the excess must be accommodated elsewhere, and in the limbs as parts of that "elsewhere." But it does not need scientific investigation to tell us that much blood is in the warm skin during healthy sleep. If the skin holds more, the brain must hold less,

since the volume of the blood in the body is constant. That the blood-pressure in the arteries actually falls in sleep has been proved experimentally by the Russian physiologist, Tarchanoff.

In yet another way can we prove that there is an altered distribution of blood in the brain. The genius of Mosso devised the method of "the human balance," which consists in a person awake being accurately balanced on a table and allowed to fall asleep; as he does so, the foot end of the table sinks. The angle through which the table dips is a measure of the depth of sleep. The change in weight may be as much as corresponds to the weight of 260 c.c. of blood.

These and other researches have shown that this altered distribution of blood begins *before* sleep has set in; in other words, the blood leaving the brain is a cause of sleepiness (somnolence). Sleep is "propter," not merely "post hoc." Thus before sea-sickness some people become somnolent; here the blood is leaving the head, as is shown by the pallor of the face.

In extreme cold—in balloons, at high altitudes—people become sleepy; here the vigour of the cerebral circulation is greatly diminished by the enfeebled heart suffering from depression of vitality through the general depression from loss of heat.

The question at once arises, What is normally the cause of this diminution of blood to the brain which precedes sleep? The answer is, dilatation of the blood-vessels in the skin and the viscera of the abdomen; both factors to co-operate; Professor Howell thinks the former the more important, Mr. Leonard Hill the latter. Either would tend to cause the fall of general blood-pressure which occurs.

But we want to know more than this; for naturally one asks, Why do the peripheral arterioles dilate towards evening? It is due probably to fatigue of the vaso-motor centre as the day wears on; the toxins of fatigue begin to inhibit the excitability of the vaso-constrictor centre, which accordingly innervates less intensely the cutaneous and visceral arterioles. This fatigue-depression of the vaso-motor centre is phasic or

rhythmic; normally it comes on towards evening and increases until sleep supervenes. We know that as evening comes on there is more blood in the skin than there was earlier in the day: people's collars and rings feel tighter in the evening. The rhythm of the activity of this centre is in some way probably related to the great diurnal rhythm of day and night.

This was illustrated in the extraordinary case of a boy abandoned in the streets of Nuremberg at the age of seventeen. His childhood had been spent in "absolute solitude, having no knowledge of men, animals, or plants." He always went to sleep as soon as the sun had set. Old people, from the weakness of their cerebral circulation, go off to sleep frequently for short periods especially when in a sitting posture. This was a feature of the last few months of the life of Queen Victoria; Her Majesty would often be found asleep in the carriage.

The last causal factor in the onset of sleep is the absence of mental occupation or activity. Everybody knows that "any-

thing on the mind" will prevent sleep, whether that something be grief, joy, or a mathematical problem. Unconsciousness is incompatible with activity of the brain. No doubt this psychical factor is intimately dependent upon other conditions, the cardiac, and the sensorial. Thus the mind will be very much awake after experiencing an unusually vivid series of sensations; the children after their visit to the pantomime or the menagerie are too excited to sleep. According as there is increased blood-flow through the brain from any cause there will be increased flow of ideas through the mind. Thus it is that conversational powers are so much better after than before dinner.

Now just as there are four types of sleep, so there are *four* corresponding *types of insomnia*: a chemical, a vascular, a sensory, and a psychic.

In the chemical type the brain-cells are kept awake (stimulated) by fatigue-toxins of an unusual kind or by drugs, for instance caffeine or a *small* quantity of opium.

In the vascular type the excited heart is

driving blood too vigorously through the cerebral vessels, with the result that the brain-cells cannot rest.

In the sensory type of insomnia, sensations, it matters not of what kind, cannot be excluded and so the mind cannot rest. In the psychic type the presence of thoughts, problems, or emotions is keeping the highest portions of the brain in a state of activity.

What one would have considered intensely distracting in the way of thoughts have not always debarred from sleep; condemned criminals have slept soundly the night before execution, while some people pass sleepless nights if they know that they *must* get up early the next morning. The psychic causes of sleep are precisely those on which to give advice is supremely supererogatory. There is no use telling a man in love that "there are plenty more fish in the sea," or a man wrestling with a mathematical problem that "much study is a weariness of the flesh," or a person who has not got the rent ready that is due to-morrow that "to-morrow

never comes." The mind is obsessed, and so long as it is sleep is impossible or will only come after hours of tossing. Responsibility, worry, and grief must come to all at some time or another during life, else the life they are living is not life at all, but a soulless, bloodless simulacrum. As long as we "walk through the valley of the shadow of death," times must come of tears and sighs and sleepless eyes—but merciful fatigue is never far distant, and therefore, if it is true (as we have been so often told) that sleep *is* the image of death, then there is certainly for each one of us every morning a glorious protoplasmic resurrection.

CHAPTER V

LATENT LIFE, OR APPARENT DEATH

In the present chapter let us look more particularly into the curious middle state known as latent life, which resembles death much more closely than sleep does.

To the ordinary person nothing seems easier than to be able to distinguish between life and death, or, to be less abstract, between a living animal and a dead one. A child can tell a dead tree in the woods when it sees one. A person naturally thinks of the entire organism as alive, the signs of its life being that it is warm, that it breathes, that its heart beats and that it is aware of its surroundings, all of which is in sharp contrast with the cold, still, unconscious corpse in which the beating of the heart has ceased for ever. If asked to say whether an animal lying in the road was alive or dead, we

should at once try to arouse it, stimulate it as it is technically called, and if, on its receiving the stimulus—a shout, a pin-prick, a touch with the boot—the animal jumped up or turned over, you would at once say it was alive ; if it failed to do so, you would assume it was dead. In physiological language, an animal on being stimulated will if alive respond in some way or other, if dead it will not. Exactly the same reasoning applies to the isolated tissues, heart, muscle, etc., of the body ; if they are alive they respond to stimulation, if dead they do not.

Response or reaction to the environment is, then, the great criterion of life ; this property of being able to respond to a stimulus is called affectability or irritability. A dead organism, having no affectability, fails to respond to stimulation ; it is dead to the world. Response to stimulus is the chief test of livingness whether of individual, organ, tissue, or cell. Now we can state quite precisely the differences between a living animal and a dead one, for at present we are leaving plants out of account.

A living animal organism is characterized by the following capabilities or powers:

1. It can feed, that is assimilate to itself material (food) chemically often quite unlike the composition of its own tissues, for cannibalism is not exactly a common custom. This digestion and incorporation involves excretion, or the getting rid of material useless or injurious to the organism. The one word "metabolism" covers all the changes wrought on matter by a living being.

2. It can transform the potential energy of food into the kinetic energy of heat (animal heat), movement, nerve-energy, and electric current. A living organism under this aspect is an energy-transforming machine.

3. It is able to resist infection and, within limits, all agencies tending to compromise its integrity. It can manufacture antibodies, as they are called; they are biochemical responses to biochemical insults.

4. The living body has a life-history;

it has birth, youth, prime, senescence. In other words, it goes through an orderly sequence of irreversible phases. Every living thing springs from an egg or ovum, which, being duly fertilized, enters on a course of evolution or progressive unfolding of its tissues from the simple to the complex, from the few to the many, from the immature to the mature. The living being is never stationary; it has time relations. It is interesting to note that amid this constant change of material the personality or identity of the organism is maintained.

5. Finally, it can reproduce itself: clearly all organisms that are to survive must be capable of reproducing their kind. Except in the lowest forms, where buds can be cast off and thereafter attain to the likeness of the parent (asexual method), the method is the sexual, which requires the congress of two physiologically different individuals, the male and female parents from whom proceeds the new organism.

None of these things can a dead organism do; it cannot feed, nor excrete nor produce heat; it passes through no sequence

of events, it cannot reproduce itself, and finally it putrefies. Death, then, is the permanent impossibility of exhibiting the characteristics of vitality; it is an irreversible state. In the author's terminology, death is a state of infinite physiological inertia, the biological antipodes of affectability. Livingness is exhibited not only by entire organisms, but by their constituent tissues and cells. For tissues and cells can feed, excrete, produce heat and electric current, give rise to antibodies, and, finally, produce new elements. The reason for the life of the entire individual is that each of its ultimate constituents is alive.

In judging of the livingness of isolated organs, tissues, and cells we must have some convenient method capable of being followed out in the laboratory. The signs of life in the laboratory are, for instance, in the case of muscle—it absorbs oxygen, it gives out carbon dioxide, it produces heat, it twitches or contracts, and finally it can evolve an electric current.

Of all these signs of life, the one men-

tioned last is by far the most delicate, for tissues which have long since ceased to exchange gases with the atmosphere, and even to produce detectable heat, can still give an electric current on being adequately stimulated. The isolated heart of the frog or tortoise, for long after its gaseous exchanges and heat-production are imperceptible, can yield distinct electric currents to that sensitive instrument the galvanometer. Even after the heart has ceased to beat, as far as the unaided eye is concerned, it can still spontaneously evince electric disturbance; tissues other than the heart of course need first a stimulus.

The evolution of electric current is, then, the most delicate sign of life, and it is also the last sign. But it is also the first sign of life, for the late Professor A. D. Waller, the English physiologist, has shown that the hen's egg will give an electric current just as soon as the almost invisible speck representing the future chick is constituted on the surface of the yolk. Such widely different things as brain, liver, heart, muscle, eye, seeds,

green leaves, fruits, and seaweed will, on being stimulated, produce an electric current. These currents are, of course, of very feeble voltage; only in electric eels and other fishes are they so powerful as to cause the death of other animals. The electric current, since it is producible as soon as a being can be said to be alive at all, and since it can be recorded long after every other sign of life is gone, has been picturesquely called the alpha and omega of animate existence.

Now it is clear that there must be *degrees* of livingness in tissues, for, whereas some like liver and heart are intensely alive, others such as the upper layers of the skin have little vitality, and yet others —enamel of teeth and horn of nail and hair—are absolutely dead. Thus when Horace said "non omnis moriar" he was not even altogether alive. It is similar with entire organisms; we can construct a scale of all degrees of livingness from the great physical and mental vitality of a Helmholtz, a Gladstone, or a Kelvin at one end, down to the somnolent stupidity

of the country yokel at the other. Furthermore, vitality undergoes diurnal variations, being at its maximum at about 10 o'clock in the forenoon and at its minimum between 3 and 4 o'clock a.m., a time when it is well known those who are moribund usually die. Napoleon, whose saying that an army marched on its stomach is based on sound physiology, used to declare that what concerned him was the state of a man's courage at 4 a.m.

Compare the degree of vitality enjoyed by a healthy young man just returned from a holiday with the depression of the hopeless sufferer from melancholia. In melancholia all the tissues are demonstrably less alive, less oxygen is absorbed, less carbon dioxide excreted, and less heat evolved.

The late Dr. Waller showed that a green apple gives on stimulation a more intense electric response than a ripe one, for the excellent reason that it is younger. But that is not all: if the green apple and the ripe one be very nearly killed by having had sent through them a very

violent electric stimulus (shock), both apples for a time will be unable to show electric current, but the young apple will revive sooner than the older one. The analogy with human beings is surprisingly close.

Medical thought at the present time is greatly interested in that other sign of vitality, namely, resistance to infection, the power of making antibodies of which the class called antitoxins is the best known. Now vegetables and animals can enter into a certain state in which, although they are not showing any of the ordinary signs of life, they are nevertheless not dead: this state is called latent life. The only sign of livingness exhibited in latent life is the electric current of Waller; in all other respects the organisms or tissues may be regarded as dead. They are taking in no oxygen, giving out no carbon dioxide, evolving no heat and are performing no movements, so that the condition is also called apparent death. A dried seed is a good example of this condition; it seems dead, but the ordinary person

can ascertain whether or not it is dead by planting it in the ground and waiting until it has or has not produced a plant. If it produces a plant it was alive, but we have lost our seed, although we have gained a plant. Similarly, to know whether an egg is alive (impregnated) or not, "wait and see" whether it hatches; if it does it was alive, but again we have lost our egg if we have gained a chick. Waller's method with seeds or an egg is to send a strong (electric) shock through it; if it produces an electric response it is alive.

Not only has Waller used the electric response as a sign of life, he has also made it a quantitative measure of the degree of vitality. He selected a number of seeds of Phaseolus from one to five years old and tested one of each age for the production of electric current. The responses in fractions of a volt were for the five years respectively—0·0170; 0·0052; 0·0043; 0·0036; and 0·0014—a very remarkable demonstration of the statistical aspect of livingness. The older the seed the less the response; it is what one would

have supposed, but it could not be taken for granted.

These seeds were dry, they were to all intents and purposes dead; they were lying in a pill-box doing nothing vital, but they were not dead, they were in latent life; they could germinate and they could produce electric current. Drying is an excellent method for sending many living things into *la vie latente.* It used to be asserted that wheat found in mummy cases could germinate. Mariette, the Egyptologist, definitely denies that this wheat can do so; placed in water it becomes a clayey pulp. It is true, however, that seeds of the gorse have germinated after being 30 years in latent life; seeds after 87 years in a herbarium have sprouted, and seeds kept for 200 years have actually produced plants. Becquerel, the French naturalist, submitted the seeds of wheat, mustard, and lucerne to the following drastic treatment—having perforated the seed coats, he dried the seeds in a vacuum at 40° C. and sealed up the seeds in a tube almost exhausted of air for one year, sub-

mitted them to the temperature of liquid air (minus 198° C.) for three weeks and of liquid hydrogen (minus 250° C.) for three days and then placed them on moist cotton wool, when they germinated! Some fairy tales are not so interesting as this.

But it seems that even animal organisms can enter into latent life. Ever since 1719 this has been known, for the Dutch naturalist Leeuwenhoek found minute animals called Rotifers dried up in mud apparently dead but able to live again when moistened with water. This rising as it were from the dead is called Anabiosis. Besides the Rotifera, or wheel animalcules, other minute animals, the Tardigrada, or bear animalcules, the Anguillulidæ, or paste eels, and some kinds of thread worms are all known to be able to survive extreme degrees of desiccation for as long as twelve years. These animals are in a state very closely resembling death, but it is not death, for it can be recovered from. Death is the permanent impossibility of living again; it is an irreversible state, which latent life is not. From death Science knows no recall, no

resurrection, but from latent life it does. From it an organism can either go back to full life or on to death. Latent life rather than sleep is the image of death.

Obviously, only simple or lowly animals can live after being dried up; and yet the wheel animalcules are not so extremely simple, seeing that they have a nervous system. A much more widely applicable method of sending organisms into latent life is that of cooling them. By abstracting their heat, a large number of very different sorts of plants and animals can be so devitalized as to become apparently dead; that they are not dead is known only from the fact that on being thawed they can evince the usual signs of life.

The bacteria, the simplest of all plants, show extraordinary resistance to refrigeration, for it has been proved that they can be frozen down to the temperature of liquid air and yet retain their vitality. The late Professor MacFadyen chilled certain disease-producing organisms down to the temperature of liquid air and made them so brittle that they could be powdered up

in a mortar, but after all this severe treatment it was found that on being thawed they had retained their disease-producing properties. The bacteria of putrefaction have been frozen at the temperature of solid alcohol and have yet on thawing retained their full capacity to cause putrefaction. These frozen bacteria were evidently not dead but only in latent life.

The fact that the "germs" of decomposition of meat can be sent into latent life by being frozen is taken advantage of in the commercial process of cold storage. The beef is dead and, as we all know, liable to putrefy unless it is frozen. Were there no germs of putrefaction on the meat it would not putrefy; but it does not "go bad" on its journey from the Antipodes because the germs of putrefaction on it are by the refrigeration sent into latent life. That they are merely in suspended animation and not dead is proved by the familiar fact that as soon as the meat is thawed out it will "go bad" with great rapidity, which means that the bacteria on it and in it have returned to their active vital

condition of fermenting or decomposing the meat.

Recent research on the preservation of fruit in refrigerators has shown that the spores of the Black Spot fungus can be kept for six months at minus five degrees centigrade and yet germinate at ordinary temperatures. It is a curious fungus, for its optimum temperature is as low as zero centigrade. The whole problem of the storage of fruit is being studied in the light of recent work in Biology. Fruits—apples and pears—pulled off the tree and kept for some time are still alive; in fact they are still breathing, that is taking in oxygen and giving out carbon dioxide; they are not dead, they are not even in latent life. They are not dead because, for one thing, they are not putrefying, and in fact their tissues and ferments are still too active to permit of their being described as in latent life. They are, as everyone knows, ripening, and this consists in their ferments forming sugar out of unsweet materials. By being chilled, however, fruits can be brought into latent life, which

is evidently the condition to have them in if storage for a long time is desired.

Apples keep best at one degree centigrade; freezing the fruit destroys it because it breaks up the structure of the living cells and kills them and so prepares them for active decomposition. Of course, to freeze a solid mass like an apple requires a temperature lower than the freezing point of water (0° C.). Apples are found to live best, that is "keep" best, in an atmosphere containing more oxygen and much more carbon dioxide than does the ordinary air.

Coming now to the animal kingdom, we find that by the application of cold many organisms can be sent into latent life. Sir Ernest Shackleton has reported that in the South Polar seas there are certain lowly marine organisms frozen motionless in the ice for ten months in the year, but able to swim about actively for the other two. They pass alternately from life to latent life, from apparent death to life; they have a yearly anabiosis. As one might expect, the cold-blooded animals

survive degrees of refrigeration which would kill the warm-blooded. Physiologists know that snails, water beetles, insects, frogs, and fish can withstand temperatures so low that warm-blooded animals would be killed outright.

Sir John Franklin in his Polar Expedition of 1820 reported on carp fish frozen so hard that the intestines of some of them could be taken out *en bloc*, and yet that others of the same batch of fish revived and moved actively when thawed before a fire. Fishes frozen in a block of ice at minus 15° C. have been known to survive, although the bodies of some of their companions were so hard they could be powdered up along with the ice. A fish has been frozen in a block of ice, then sawn in half along with the ice, and each half has, on being melted, performed active movements.

The louse (Pediculus) has been known to be alive after no fewer than seven days' submersion in freezing water. The frog is an animal that can withstand being frozen without being killed. It is possible to exhibit at the beginning of a lecture

on physiology a frog frozen so stiff that it can be held out horizontally by the toes like a piece of board, and yet, on allowing the frog to thaw, to show that it can skip about before the end of the hour like any other healthy animal.

On the approach of winter frogs descend into the mud at the bottom of the pond and there rest in latent life until next spring; that is their form of hibernation. In all probability they are not frozen stiff, but their life-processes must be at an exceedingly low ebb. Snakes behave in a similar manner. The French scientist Pictet has stated that frogs can endure a temperature of minus 28° C. This seemed so very low a temperature for frogs to live through that I made a number of experiments on the subject to gain further information.

I found that frogs could be frozen stiff as regards their skin and muscles and yet remain alive inasmuch as their hearts were still beating although probably not carrying on an efficient circulation of blood. It was found that if ice formed

around the internal organs and especially around the heart, they could not survive. It was shown that, in the case of a frog whose mouth temperature had been minus 7·5° C. for three hours, and whose heart had stopped beating, that the muscles of the eyes and of the tongue would still respond by twitching when stimulated by powerful electric shocks. It was found that the duration of chilling had an important effect; a frog whose internal temperature was minus 10° C. was alive at the end of the first hour but not at the end of the second. Temperatures lower than minus 10° C., if the frogs survived them, could have been endured only for comparatively short periods.

When we come to the warm-blooded animals, we find that, as might be expected, they cannot withstand anything like the extreme degrees of drying and chilling which the more lowly and hardy animals are able to endure. Nevertheless tissue changes can become so depressed in some of the warm-blooded animals that a state virtually of latent life can be entered

upon. Such a condition is seen in the hibernation or winter sleep of bears, tortoises, hedge-hogs, dormice, and marmosets. On the approach of winter these animals, having already laid on a large store of fat, retire into some place of shelter, and, ceasing to breathe, go into a deep sleep until the spring. The amount of oxygen they consume is the irreducible minimum, the heat they evolve is very small; they live on their own body-fat and other tissues, for of course they eat no food at all. When they emerge next year they are extremely thin.

We learn from these cases of hibernation that even after breathing ceases the animal may yet live; but it may surprise some readers to learn that even after the heart has ceased beating the organism does not necessarily die all at once. The fact is, many of the tissues of the body live for a long time after the body as a whole is dead. In more technical language this is local life after somatic death. Thus some muscles live for hours, and the skin and hair roots live for days after general or

somatic death. It is known that if the face be shaved *immediately* after death the hairs will have grown to a perceptible extent within the next day or two. In regard to the human being we pronounce the person dead when breathing has ceased and the pulse is no longer perceptible. The breathing may be so slight that only by the moisture of the breath condensing on a mirror can it be known to be going on. Shakespeare alludes to this in King Lear :

> I know when one is dead and when one lives ;
> She's dead as earth—lend me a looking-glass.
> If that her breath will moist or stain the stone,
> Why then she lives. (*Lear*, Act V, sc. 3.)

Though the pulse at the wrist be no longer felt, yet the heart may be alive, fluttering rather than beating in such a condition that if we could get at it and massage it, it would revive to some extent for a time at least. This possibility is now made use of by the surgeon whose patient's heart may stop during an abdominal operation. Without loss of time he inserts his hand into the wound and strikes the heart a few gentle blows through the diaphragm,

with the result that the heart sometimes recommences beating.

It may be now asked, Can a human being enter into the state of latent life? The answer is "Yes," but in so replying we must recollect the kind of suspended animation which is compatible with the delicate protoplasmic structure and the complicated chemical behaviour of human tissues. No mammal, no human being can be dried up or frozen stiff like some of the lowlier creatures and yet live. What we may admit is that life in man can be retained when all the vital processes have sunk to a minimum.

What is known as trance or narcolepsy is the form which latent life takes in the human being. Every now and again we hear of cases of persons, usually young women, going into profound and prolonged sleep from which they do not wake for weeks or months. During that time they take no food, they scarcely breathe, their heart's action is at a minimum. This is of course quite different from the hypnotic or mesmeric trance. Some people fear

this state of trance very much; they are in dread of falling into it and being buried before they are really dead. Hence they insert explicit injunctions in their will that their physician is to open a vein or in some other way assure himself that they are dead before burial is permitted.

It is doubtless true that certain persons have been buried alive in the sense that while the heart's action was still at a minimum, they have been placed in a coffin. Cases of persons "laid out" for the undertaker and reviving on his arrival are not unknown. Some persons have revived on the bier; but the number of persons buried while the body as a whole lived is in reality very small. Moribund persons have been buried at times of great confusion during plagues and epidemics.

Possibly the most famous case of narcolepsy is that of Colonel Townsend of Dublin, which has been described by the well-known Dr. Cheyne:

"He could die or expire when he pleased, and yet . . . by an effort he could come to

life again. He composed himself on his back and lay in a still posture for some time. . . . I found his pulse sink gradually till at last I could not feel any by the most exact and nice touch.

"Dr. Baynard could not feel the least motion in the breast nor Dr. Skrine perceive the least soil on the bright mirror he held to his mouth . . . could not discover the least symptom of life in him. We began to conclude he had carried the experiment too far, and at last we were satisfied he was actually dead. . . . By nine in the morning . . . as we were going away we observed some motion about the body, and upon examination found his pulse and the motion of his heart gradually returning; he began to breathe heavily and speak softly."

Still more extraordinary are the narratives of the Fakirs of India, who are said to allow themselves to be built up in sealed tombs for weeks without food and to be alive at the end of that time. Reports of these cases of human suspended animation are now too numerous and too well

authenticated by European eye-witnesses of unimpeachable integrity to be set aside as either in themselves untrue or as due to collective hallucination.

Many people if asked to give an example of suspended animation would refer to the case of some one apparently dead through drowning. Strictly speaking, a person rescued from drowning may be moribund, but not quite dead; there is, in physiological language, enough local tissue life present to ensure the living of the entire organism provided oxygen be got into the blood and so to the tissues before they utterly perish. Therefore, still speaking strictly, a drowned person is *not* in latent life, not in a condition which can be kept up indefinitely and which will pass into full life in due time.

On the contrary, a drowned person is dying; but most fortunately the several tissues do not die the moment the individual as a whole dies, but can survive long enough to be revivable if only enough oxygen can reach them sufficiently soon. Of course, it all depends on the heart and nervous

system; if the heart is dead the individual cannot live again; if the heart, though moribund, is capable of absorbing oxygen and of beating again, the individual will live provided also his central nervous system and particularly the centre for breathing is still alive. In the actual practice of "first aid," it is well to assume that the person is alive and to persevere with artificial respiration while keeping the body warm for as long a time as two or three hours before pronouncing life extinct.

The tales of frogs being found alive in the midst of blocks of marble just broken open in the quarry have been the subject of much controversy, but they are not now credited.

The latent life of isolated tissues is a remarkable phenomenon. Dr. Alexis Carrel of the Rockefeller Institute of Medical Research has actually been successful in causing tissues isolated from chick embryos to grow in glass vessels in a drop of blood-plasma for as long a time as two or three years at ordinary temperatures. When, however, this "culture" was placed

in a refrigerator all growth was stopped, and as long as it was chilled it exhibited no growth, the isolated tissues having gone into latent life. Fragments of heart muscle can similarly be kept *in vitro* for two or three months; these beat spontaneously during all that period but ceased beating when sufficiently chilled.

In some few cases latent life seems to be capable of being entered upon after drastic treatment with certain chemicals. The insect, the louse, is a case in point. A recent writer from Russia thus describes its powers of resistance: "The louse is one of the hardiest and most prolific of pests: the majority of disinfectants and insecticides he scorns; he can survive having drops of pure alcohol or chloroform dropped on him."

The state of latent life may be regarded as a condition of high resistance towards those conditions which make for death. Abstraction of water and of heat are both of them conditions tending towards death; they involve speedy death in many organisms. But such animals or plants as

can reduce their metabolism (respiration and heat-production) to the irreducible minimum may escape death in the half-way house of latent life. This is apparent death, not real death, which is a condition that can *not* be recovered from. In the author's terminology, the property of affectability has fallen to a minimum, that of physiological inertia has risen towards a maximum, the absolute maximum being reached in death itself.

All poisons tend to kill protoplasm, to immobilize it; death is the complete immobilization of living molecules; whereas latent life is a degree or stage towards this end. Any agencies like desiccation or refrigeration, or reagents like alcohol or chloroform which diminish molecular mobility, tend to render life latent and thereafter to extinguish it. Upon this partial immobilization depends the efficacy of a large number of our drugs and the action of many poisons. To abolish consciousness we administer chloroform, a substance which, by uniting for a time with certain of the chemically active radicles constitut-

ing protoplasm, immobilizes more or less completely the whole molecular complex. The immobilization of the molecules of the cells of the brain has as its psychical correlative the disappearance of consciousness. The anæsthetic really tends to immobilize the brain cells, the cells of the breathing centre, and the heart cells; what the surgeon wants is cerebral immobilization with its counterpart unconsciousness to pain without heart paralysis which would mean death.

The organism in latent life is not dead, for it is capable of manifesting once more all the vital attributes which no dead thing can do. It is, however, very far from being fully alive, for it may be manifesting none of the attributes of livingness save the possibility of developing a feeble electric current which can be detected only by a delicate apparatus accessible to biological experts. It is not dead, however much it looks it.

In living matter, the molecular whirl is at its intensest; in latent life the molecular whirl is for a time arrested; in death

the molecular whirl has been stopped for ever. In life the dancers are in the mazes of an elaborate figure; in latent life each individual is standing stock still; in death every dancer has fallen over. In latent life the weights of the protoplasmic clock have been seized by a mysterious hand; in death they have descended to their full extent and cannot be wound up again, for the cord is broken. In latent life there is only a stoppage, in death the end has been reached. In life "the sands of time" are running out rapidly; in latent life the stream has stopped; in death the sand is all in the lower globe.

In a sense very different from what the author of the lines meant it, yet in a sense profoundly true:

> 'Tis not the whole of life to live,
> Nor all of death to die.

CHAPTER VI

COLOURED THINKING AND ALLIED CONDITIONS

In the remaining chapters we shall take into consideration certain aspects of mental life, and first of all a very strange though not exceedingly rare attribute of the life of the mind known as coloured thinking.

When one sensation, say a sound, involuntarily calls up another sensation, say that of light or colour, we say the percipient has linked sensations, or one of the synæsthesiæ. This particular form, coloured hearing (*audition colorée, farbiges Hören*), is by far the commonest.

Musicians seem peculiarly liable to experience colours when tones or voices are heard; thus we read of organ notes as being violet, violin green, a human voice as brown or yellow, and so on. Some coloured hearers always see dark colours

along with notes of low pitch and pale or bright colours with those of high pitch. Such linked sensations are called sound- or phono-photisms. Much rarer are the cases where the other sensations produce light or colour, but such are known; thus we can have—an odour calling up a colour (an olfacto-photoism); a taste calling up a colour (a gusto-photism); heat or cold sensations calling up a colour (thermo-photism); and lastly pain calling up a colour (an algeso-photism). Specific examples of these are—smell of musk recalling scarlet and gold; an acid taste being described as yellow; a cold sensation as white, rheumatic pains grey, and toothache black.

Examples of linked sensations taken from my notebook at random are—Who is that speaking in a dark-brown voice?; Schubert's music calls up a sunny green; full-toned speech is like a coloured picture, whispering is like a black-and-white engraving, a musty smell is like grey and red, an acid taste calls up yellow, something hot in the mouth gives a sense of

whiteness. "The gorse in bloom is like a thousand silver trumpets"; bright lights arouse the sounds of high-pitched notes; dim or dull colours those of low-pitched. Schubert's music calls up the smell of young pine trees. "The sharp perfume had in it something provocative and exciting that was like a sound." "Scarlet was like the sound of a trumpet." "To remember some words is to touch a flower."

Beethoven said he would make the blind girl "hear moonlight."

"I can smell the sunset."

Distinct both from synæsthesia and from coloured thinking is the thought-form or psychogram.

It is the faculty of seeing certain concepts—the numerals, days of the week, months of the year, the alphabet, and so forth—as occupying collectively some definite positions in space. Thus certain seers always think of the numerals one to a hundred as arranged in the form of a ladder stretching up into the sky to the right or the left, as the case may be. Other seers think of the days of the week

as on a curve with Wednesday at the apex; still others visualize the months as arranged on a rainbow or other huge form dying away into space. Thought-forms may be yet more irregular, as when the alphabet is exteriorized in the form of steps and stairs ascending or descending from the observer.

Coloured thinking proper is the association of a colour with an exteriorized concept. Certain persons find that they cannot attentively think of anything, cannot visualize it, without its arousing or suggesting colour. This may be called chromatic mentation, or psycho-chromæsthesia, and such persons coloured thinkers or psycho-chromæsthetes. The concepts most commonly coloured are the hours of the day, the days of the week, the months of the year, the letters of the alphabet, proper names, and so forth. To those who never experience this sort of thing it is unintelligible. There is no kind of agreement between the colours associated with any one thought on the part of a number of coloured thinkers. Thus the vowel "u" is for eight different persons

thought of as in eight different colours—grey-white, yellow, black, brown, blue, green, brown-yellow, and dark grey respectively. To one person August is white, to another crimson, to a third heliotrope. There is no attempt at agreement.

The following are the characteristics of this curious capacity:

1. The very early age at which these associations were fixed. "Ever since I can remember," "Ever since childhood I have always had," "I do not remember the time when I had not," etc., are the phrases used by coloured thinkers asked when they first noticed the phenomenon.

Children of only nine and ten years give most satisfactory and definite accounts of their psychochromes. This feature was recognized by Francis Galton in his classic examination of the subject in 1883.[1]

2. The second characteristic of coloured thinking is the unchangeableness of the colour thought of. Middle-aged people tell us there has been no alteration in the

[1] *Inquiries into Human Faculty and its Development*: MacMillan, London, 1883.

colours nor even in the tints and shades of them ever since they can remember having thought in colours at all. Galton's remarks were, "They are very little altered by the accident of education," "they are due to 'Nature not nurture.'"

Just as their origination is, apparently, not due to the influence of the environment, so the environment exercises no modifying influence on them during a long life.

3. The third characteristic of psychochromes is the extreme definiteness in the minds of their possessors. Contrary to what might reasonably be expected, the colours attached to concepts are not vague or incapable of accurate verbal description. A coloured thinker is most fastidious in the choice of terms to give adequate expression to his mental imagery. One of these is not content in speaking of September as grey, he must call it steel-grey, another speaks of dull white, silvery white, the colour of watered silk, and so on. One child speaks of March as "art blue"; another of 6 p.m. as "pink*ish*." The degree of chromatic precision which

can be given by coloured thinkers to their visualizings is as extraordinary as any of the extraordinary things connected with this curious subject.

4. The fourth characteristic is the complete non-agreement between the various colours attached to the same concept in the minds of different coloured thinkers. Thus nine persons think of Tuesday thus —brown, purple, dark blue, brown, blue, white, black, pink, and blue. Again, September is thought of as pale yellow, steel grey, and orange by three different coloured thinkers respectively. Once more, the vowel "i" is thought of as black, red-violet, yellow, white, and red respectively by five persons gifted with chromatic mentation; the colours are essentially one's own; these psychochromes are not shared.

5. The fifth characteristic is the hereditary nature of the condition. Galton's own phrase was "very hereditary." The extremely early age at which coloured thinking reveals itself would of itself indicate that this propensity was either

hereditary or congenital. Heredity from father to son is quite common. In a case well known to myself, the brother, nephew, and first cousin of a coloured thinker are all coloured thinkers. In common language, it "runs in families," but there is no more unanimity in the family in this obscure subject than there is apt to be in many families in regard to subjects of much commoner experience. Three persons of the same family think of March as brown, steel grey, and orange respectively.

6. The sixth characteristic of coloured thinking is its unaccountableness. "I cannot account for it in any way" seems the all but universal remark made by these seers. No line of research seems to lead to any explanation of more than an occasional psychochrome. Many persons, regarding it as a childish survival, have not cared to confess to possessing it at all or have never tried to trace it to a probable source. Possibly, in some few cases, the impressions left by early picture books and paint boxes may have been responsible for some of the mental colours. In a very few instances

such an association as the following may account for the colour of a thought—"The earliest February I can remember was snowy"; through the whiteness of snow the thought of February came to be coloured white.

But it is clear that if environmental influences are operative in anything like a large number of cases, the colours for such concepts as the months of the year ought to be far more uniform than they are. No common origin of external source can make one person think of August as white, another brown, another yellow, a fourth crimson. If August is white to one person because it is the month of white harvest, then it ought to be white to all persons capable of receiving any impressions from the colour of harvest. But to the vast majority of persons it is perfectly absurd to think of August as having any colour at all; and to the few who think it coloured, it has by no means the same colour; all seems confusion.

A little light is thrown on coloured thinking by some consideration like the

following; psycho-chromæsthetes are liable to associate with concepts of something pleasant the colours they like, and with things unpleasant the colours they dislike. Ellen Thorneycroft Fowler, in a private communication, was good enough to inform me that she has always associated with herself, her birthday, the month of her birthday and the first letter of the name, the colour blue because blue is her favourite colour. But on the other hand, another person whose favourite colour is heliotrope never associates this colour with any concept whatever; all seems confusion.

The associating of a colour with a person is commoner than it might be thought; it is known as "coloured individuation."

There is here and there a little method in this chromatic madness; thus, the colours of the words denoting colours themselves are appropriately coloured for most coloured thinkers; that is, white is white, black black, and so on. Again, in most cases, the colour of the initial letter determines the colour of the whole word; if "d" is black, then *decide* will be black;

if the numeral 1 is white, then 10, 100, 1000, and so on, will all be white. It might be thought that the coloured thought of a word would be the colour of the sum of the colours of the letters composing the word; but this is not so; for in one case "Tuesday" is white, and the component colours are blue-black, grey, brown, yellow, brown, white, and yellow, colours which, when mixed, could not possibly "make" white.

The relative frequency of the colours met with on analysing 100 psychochromes is: white 24 %, brown 24 %, black 17 %, yellow 11 %, green 7 %, blue 5 %, red 4 %, pink 3 %, cream 3 %, orange 1 %, and purple 1 %.

Coloured thinking is by no means confined to women, as some persons have assumed; I have found it very nearly as frequent in men. It should be remarked that the colours are never present to consciousness with the vividness of an hallucination, probably because they are related to concepts and not to sensations. They are not present all the time to the seer as

he speaks or reads, but only when compelled for some reason or another to visualize (exteriorize) his concepts. He then finds he cannot visualize certain concepts as uncoloured.

Galton believed that coloured thinkers were as a rule above rather than below the intellectual average. He mentions a number of well-known men to which I have been able to add some equally distinguished names. It is certain that coloured thinkers are not abnormal mentally; it would be more correct to describe them as in this respect supra-normal in the same way that geniuses are supra-normal. Just as genius, if not inherited, cannot be acquired, so neither can coloured thinking.

CHAPTER VII

NERVES AND NERVOUSNESS

Possibly no terms are so loosely used as "nerves" and "nervousness." Owing to the prevailing ignorance about the nervous system nerves have become of much profit to the quack and the charlatan. Before we attempt to understand in what "nervousness" consists, and why some people are "nervous" and others not, we should find out what a nervous system does, what the possession of it means, and what would be the result of our not having one. The central nervous system is a mass of very highly specialized living matter (nerve-cells) contained inside the skull and spinal column in order to be protected from injury from outside. Into and out of this mass of nerve-cells run certain nerves from and to the "periphery," by which we mean all the body exclusive of the

central nervous system itself. Most of the nerves going in carry impulses which arouse sensations, most of the nerves going out carry out impulses which arouse movement; by the former the environment acts on us, by the latter we act on the environment.

The nervous system as a whole is *the* great means of communication between one part of the body and another; without it we should be totally unaware of what was going on around us. We should have no sensations and no pain; although possessing eyes we should not see, though having ears we should not hear; and, not having any sensations, we should have no emotions and no ideas, since these are higher mental states compounded of the more fundamental states of sensation and perception. Of course we should have no memory, as there would be nothing to register memories in.

Again, if we had no nervous system, we should not be able to move a muscle when we wished; no matter in what danger we found ourselves we should be powerless

to escape from it. One part of the body would not have the least idea where the other part was, what it was doing, or what it wanted: we should have no knowledge of the world around us or of our relationship to it. We could initiate no bodily activity, and so would be powerless to make any change whatever in the relations between the environment and ourselves. But by means of the afferent nerves the centres do receive information regarding both the body and the outside world, and, in consequence, the individual, through his centres and efferent nerves, can constantly adjust his body to the changing conditions of the environment.

The management of an army is a good analogy with the working of the nervous system. The army council—a few men—we may liken to the highest parts of the brain, the intelligence department and signallers to the afferent nerves, the rank and file of the soldiers to the muscles—the ultimate executants of the orders issued by the council. Now the soldiers, left to themselves, would never of themselves

engage in any plan of concerted action. They must be drilled, made to execute first independent and then corporate movements in accordance with definite orders, the meaning of which they have previously learned. The men must be arranged in squads, companies, regiments and battalions, and must go through manœuvres from time to time to practise what would be required of them in actual warfare.

But in order that the army council issue appropriate commands, it must be kept informed as to the condition, number, and distribution of all the units constituting the army. The soldiers are the muscles: if left to themselves—that is, not attended to by the central nervous system—they might act spontaneously from time to time, but not always in a manner calculated to promote the well-being of the organism as a whole of which they form the constituent parts. The men must be drilled by sergeants who take orders from junior officers, who obey superior officers, who in turn obey orders ultimately emanating from the council at the War Office. In-

directly, then, this council issues orders to each individual soldier in the army.

Similarly the brain is in touch with each muscle, which it also drills and exercises and keeps in readiness for future activity, a state we call "tone." The muscles, if not in constant functional connexion with the nerve-centres through the efferent nerves, would become toneless, slack, unready to contract when a motor impulse (command to action) arrived. But the very opposite is what we find: muscles duly innervated have a certain degree of tension, are ready to shorten after only an exceedingly brief time from the instant of receiving the message. Muscles not thus innervated, even though well supplied with blood would not be in a perfect state of health, would become "a law unto themselves," and therefore be unrelated to their neighbours' needs.

This unfailing outflow of impulses from the cells of the central nervous system to the periphery—to muscles, blood-vessels, glands, and possibly other tissues—is known as *innervation*. Innervation really means

being attended to by the central nervous system; it is not being given strength to do work, but it is being kept in readiness to do work—a very different thing. It is being neurally supervised. Innervation is not the commissariat: the blood supplies the food; the blood is the canteen; each muscle must absorb its own nourishment, but by means of innervation it will be constantly kept "up to the mark," drilled, made tonic and ready for action.

Innervation is each soldier's knowing that those in authority over him have not forgotten about him, that messages have been duly sent out to order his food to be brought into camp, that orders have been received as to how each minute of his day is to be occupied, and so on. A command to action imparts no strength to act, but it constitutes a necessary antecedent condition for an attentive, well-drilled soldier to obey on the shortest notice in the best possible manner. This is what tone does for muscles; it keeps them ready. This outflow of what we may conveniently call tonic impulses has

nothing to do with our consciousness; although diminished in intensity, for instance, during sleep, it is not abolished. We do not therefore consciously or voluntarily innervate our muscles: they are innervated subconsciously. When the nervous system dies the muscles take on the flaccidity of death before they enter upon *rigor mortis*, the rigidity of death.

Now we have a good deal of evidence that the outflow of these tonic impulses is rhythmic or intermittent, in other words at a certain regular rate per second. Physiologists are not agreed as to the exact rate of arrival of these at the muscle, but efforts are being made to determine it. In what we call a voluntary muscular contraction it is extremely probable that, although the intensity of these impulses is very greatly increased, their number per second, or periodicity, remains the same. The will, then, only exaggerates the existing state of tone; this exaggerated tone is a voluntary contraction, and hence it is sometimes said that "tone is incipient contraction"—a very good

description. We know that heat is given out in voluntary contraction, but heat is also produced by a muscle in tone; and in proportion as the tone dies down so is the output of heat diminished.

This unconsciously exerted tonic influence of the nervous centres on the muscles is, like many other things, best realized when it is temporarily diminished or done away with. Thus, when a man gets a blow on the head, is "stunned," or suffers a severe and especially sudden injury, or has his central nervous system badly poisoned by alcohol or chloroform, he is quite unable to remain in a standing posture. This shock, or collapse, is due to his muscles having become more or less toneless, not so much because *they* are poisoned as because their innervation is reduced or abolished through the mechanical or chemical damage to the centres emitting the tone-maintaining impulses. The nerve-cells responsible for sending out these tone-preserving impulses are sometimes called "trophic centres," or centres related to trophism, a Greek word

meaning "growth" but now taken as synonymous with tissue-health. Trophic nerves for muscles are none other than the efferent nerves conveying impulses inducing tone in the muscles. Trophic impulses in any other sense, in so far as muscles are concerned, do not exist.

All tissues, even such an apparently lifeless one as bone (which, however, is very much alive), when from any cause deprived of their nerve-supply suffer in health, become atrophic, or atrophy. It is equally correct to speak of blood-vessels and glands as being kept in tone or in a good trophic state by reason of their innervation. Thus, if the efferent nerve to any tissue is cut, the tone of that tissue is diminished or abolished for the time being, muscles become flabby, blood-vessels paralysed or dilated, and glands quite unhealthy. It will be convenient to have a term for the nerve-cell in the centre and its outgrowth, the efferent nerve-fibre, which passes all the way from the central nervous centre to the periphery; it is "the efferent neurone." Neurone means

nerve-cell and all its processes including the long conducting process to the tissue or organ innervated. The nerve-fibres which stretch from nerve-cells to tissues have at least the property of conductivity, the power of conducting nerve-impulses. Toneless muscles are a sign of deficient innervation, a condition seen for instance typically in melancholia. It is, of course, a mental condition, but its outward and visible sign is deficiency of tone of all tissues, not only muscles but blood-vessels, glands, and skin as well.

Deficient innervation leads to deficient tone, whether that deficient innervation is due to mechanical injury to the nerve or to a depression of the emitting centre itself. In neurasthenia, again, innervation is deficient; not only are the muscles lacking in tone, but the glands, for instance the gastric glands, are deficient in chemical tone, and as they do not secrete sufficient hydrochloric acid there results the consequent nervous dyspepsia. Popularly a neurasthenic is "a nervous person"; strictly speaking such a person is suffering

from weakness of the nerve-centres, probably due to their being poisoned or not sufficiently nourished at some previous time. Nerve-centres themselves, then, can be in good health, full of vigour and nerve-energy, or they can be less vigorous, putting forth less energy, be definitely weak. Neurasthenia is only Greek for *not strength* of nerves; but in this case "nerves" means nerve-centres, since nerve-trunks are not sources of energy and merely conduct impulses.

Nerve-energy or nervous energy are terms one reads about a great deal, sees very often used in advertisements of quack medicines, and so on; but it is a thing of which the man of science has very little knowledge. There must, of course, be such a thing as nerve-energy; else nerve-centres could effect nothing and affect nobody, for "*ex nihilo nihil fit.*" The English physiological psychologist, Dr. McDougall, formerly of Oxford, has coined the word "neurine" as a convenient term for nerve-force. Although we know almost nothing about nerve-force we know a little of what

it can do, just as, although we do not know much about electricity, we know something of what it can do: both electricity and neurine pass from places of high to places of lower pressure. Returning to the centres in the spinal cord, we see that they are the sources of the nerve-energy sent out to the tissues everywhere; but we might at this point ask ourselves: do we know anything of the material basis of this nerve-energy?

The answer to-day to our question is that we do know something of the material basis of nerve energy, although only a few years ago we should have had to confess complete ignorance. We believe it to be related to microscopic granules named after a German neurologist, Nissl. These granules of Nissl are known to break up in cells that are fatigued, but to be re-formed when the cells have rested, so that we infer they are connected with the output of energy. In various mental diseases they are altered, also in alcoholic poisoning: the brain is never in good health if these granules are not of normal aspect. It is

these granules which contain a high percentage of phosphorus.

Long before they were discovered it was known that nerve-matter possessed much phosphorus, and hence arose the popular notion that to gain nerve-strength one ought to eat foods containing much phosphorus—fish and animals' brains for instance. Now while it may be good to eat fish and brains, the notion underlying the practice is based on the fallacy that we can increase the amount of any element in the tissues provided we eat food containing much of it. But the fact is we cannot in this way over-saturate the tissues with any given element: the tissues can absorb (assimilate) only a certain quantity of it corresponding to their particular chemical affinity for the substance in question. In conditions of health this affinity limit cannot be exceeded, but it is otherwise in cases of pathological deficiency of the element in question.

For instance, a healthy man by taking a great deal of iron in his diet will not cause a greater quantity of it than normal

to be retained by his tissues; but the case of a person who has not been absorbing enough iron is quite different. If now capable of absorbing it, he may, by taking foods rich in iron, bring up the iron-content of his tissues to the normal but not beyond it.

The case of phosphorus is similar. If for any reason the central nervous system has been starved of phosphorus, then food containing it may be given with advantage, but the phosphorus-content of the brain cannot be raised above the normal. Wasting diseases of the central nervous system certainly involve loss of this element which ought to be compensated for. The same reasoning applies to phosphatic tonics. They may benefit the body in certain ways, but they cannot become the means of increasing the percentage of phosphorus beyond its normal in the nerve-tissues.

We may now ask ourselves what is it that keeps up the continual outflow of impulses from the centres to the periphery? The answer is that this energy is liberated in the special granules already

alluded to by the inpouring of afferent impulses constantly arriving at the centres of the nervous system. When one thinks carefully about it one sees that a vast number of all sorts of impulses must be pouring into the nervous centres both from all the sense-organs as well as from the internal organs. Sensory impressions from the organs of vision, hearing, smell, taste, and from the skin—those of contact, pressure, heat and cold—and others of a less well defined nature from internal organs are continually arriving at the nervous system. Painful impulses are from time to time also coming in.

We are not, of course, conscious of a tenth part of all these, but they are pouring in nevertheless; some of them even in sleep when those from the skin and internal organs are still entering the nervous system. The nervous system is never without some incoming impulses, and we are powerless to prevent the entrance of the vast majority of them. Just as the hum or roar of the traffic of a great city pours into the room when the window is opened, so do the

afferent neural impulses pour into the brain and spinal cord.

The general tendency for these impulses is to cause the nerve-centres to discharge; that all the centres are not simultaneously discharged is due to the large number of co-operant conditions. Some impulses may be too feeble to arouse the first centre encountered, as when the gnat is not felt until it has stung you; but a series of such too feeble impulses may, by being summated, effect what no one of the series is able to do. Or, again, two impulses may meet and interfere with each other in such a way that no action is aroused, just as when two sound-waves meet in a particular fashion and give rise to silence, or two colour-waves to blackness. This last case is one of "inhibition by interference" of neural currents.

There is no doubt that the general incoming neural "hum" goes to produce those outflowing currents which maintain the unconscious general tissue-tone. In proportion as we cut off the multitude of incoming impulses so tone vanishes; as,

for instance, in sleep, in which no impulses are coming in from the higher sense-organs and when therefore the centres for tone to a large extent are unstimulated.

Keeping animals in the dark and in silence lowers their tone: cows kept in dark byres secrete poorer milk than those in well-lighted ones. This is due to the depressed chemical tone of the cells of the mammary gland. It has been experimentally proved that if the afferent nerves from a limb are cut, the muscles of the limb suffer diminution of tone. It is evident, therefore, that the afferent nerves and the efferent nerves are functionally very closely related through the intermediation of their common centre. The entire nerve-path from the periphery, up the afferent nerve through the centre and down the efferent nerve, is known as the "reflex nerve-arc." A vast number of the functional units of the central nervous system can be looked upon as reflex or "sensori-motor" nerve-arcs. These arcs are continually receiving impulses one way, and sending them out the other way, that is transmitting them

in one fixed direction only. The impulses which go out are not identical with those that come in; in many cases, although they come in continuously, they go out intermittently by special rhythms of their own.

Now the intensity of the response given by a centre depends upon two things—first the intensity of the incoming impulse, and secondly its own condition of being affected by the stimulus easily or the reverse (Affectability). This applies to all centres, whether those in the cord unrelated to consciousness, or those in the brain related to perceptions, emotions, ideas, and the will. Now one form of nervousness is that associated with an abnormally violent response to a stimulus. This form of nervousness is that of the "nervous temperament" as opposed to the phlegmatic, for there is more than a grain of truth in the old classification into lymphatic or phlegmatic, nervous, sanguine, and melancholic temperaments.

The nervous temperament has in recent times merely been rechristened "neurotic."

A neurotic person is one whose nerve-centres are, as compared with those of the majority of people, unduly affectable. This condition of undue affectability manifests itself in many very different ways. If a hundred people are in a hall and a door bangs loudly, three of them may jump up from their seats while the other ninety-seven merely turn their heads in the direction of the sound; the three would be for the company in question the representatives of the neurotic constitution. The physical intensity of the stimulus was presumably the same for the whole hundred, but it produced a greater effect on three of them because their nerve-centres were in a state of excitability greater than the average for the particular company in the room at the time.

Again let us suppose a hundred people come into a place where there is a large bowl of powerfully perfumed roses: ninety-seven appear indifferent and settle down to various occupations; one is visibly delighted with the odour; a second says, "That is a smell I detest," while the

third gets an attack of asthma. The last three are "nervous" as regards the neural average of the assembly. Their nervous systems are unduly affected by the perfume of roses; the form it takes in one is distinct æsthetic pleasure, in a second well-marked æsthetic pain, in a third it gives rise to a motor effect, a spasm of the muscles of the bronchial tubes. This last is known as an attack of asthma; it belongs to a class of conditions called neuroses.

Neurotic people exhibit neuroses. A neurosis is an excited or excitable state of some centre or centres of the nervous system expressing itself in an outflow of nerve-energy into such channels as injuriously affect certain organs or tissues. Nervous attacks or "attacks of nerves" may be taken as the popular synonyms for neuroses. Fits of trembling, limbs shaking, "the quivering like an aspen leaf" of the novelette, palpitation and other visible effects of fear on the approach of an ordeal ("stage-fright," examination fright), blushing, blanching, perspiring, dilatation of the pupil, and in some cases even vomiting,

are well-known results of stimulation of lower centres acted on by impulses descending from higher ones. Popularly the "nervous" person is the one who blushes, pales, or perspires too easily, whose centres for these expressions of emotion are abnormally affectable and are set in motion by conditions which would have little or no effect on a person perfectly normal as regards the nervous system, a person with what is called a "well-balanced nervous system."

What, however, is the cause of the abnormal affectability of the centres in a nervous person it would be difficult to say. In many cases it is probably due to malnutrition of the centres. Nerve substance is chemically only a very complicated form of fat, and fat people are almost never neurotic. We must not jump to the conclusion that because a person is fat his nerve-centres are of necessity well nourished, though they usually are. There are various kinds of obesity, some not indicating good nourishment; but as a rule it is lean people who are nervous.

This is, of course, what Shakespeare alludes to when he makes Cæsar say—

> Let me have men about me that are fat;
> Sleek-headed men and such as sleep o' nights;
> Yond' Cassius has a lean and hungry look:
> He thinks too much: such men are dangerous.

Of course we must distinguish between the thin, pale, neurotic person, and the thin, "wiry," fit person whose nerve-centres may indeed be affectable without being abnormally or weakly affectable. For there is the healthy, robust nervous system with plenty of nerve-energy able to be discharged, and there is the weakly, excitable system with little energy always tending to leak away. The two conditions are quite different. The ease of response to a stimulus is one thing, the amount of energy liberated by a stimulus quite another thing. The same amount of pull may fire off a pop-gun and a "twelve inch," but the amounts of energy liberated by these equally excitable mechanisms are immeasurably different. In other words, there is a high affectability coupled with the output of much nerve-energy and there

is a high affectability coupled with the output of little: this latter constitutes "irritable weakness" ("weakness to be wroth with weakness"); it is this that is the basis of neuroses, of nervousness. The brain-centres related to consciousness ought to exert on the lower centres a restraint that is learnedly called "inhibition."

Inhibition or restraint by the higher on the lower plays a large part in the activities of the central nervous system. Persons neurally robust have inhibition well developed, nervous people have it poorly developed. Inhibition is of two kinds, that unconsciously and that consciously exerted. The former is the more mechanical kind of restraint which any one centre exerts on any one lower down in the neural scale. Thus it is that when the head is cut off, the posterior part of a worm wriggles more actively than the head end; it has lost the automatic restraint of the head end. The legs of a decapitated crayfish "work" much more rapidly than in the intact animal. We may ourselves employ this form of mechanical inhibition in re-

straining, for instance, an awkward sneeze by firmly pressing on the upper lip. The otherwise uncontrollable tendency to sneeze is abolished by the impulses from the skin of the lip ; they act here as inhibitory. That it is only inhibition of the tendency and not removal of it is interestingly brought out sometimes by the fact that after a certain interval of time the sneeze may be produced in what would have been all its original intensity.

The stillness of an attentive audience is a case of unconscious inhibition ; the subsequent coughing and restlessness is evidence that it was only inhibition and not abolition that was at work. But by means of the will we can consciously inhibit or restrain. What we call "education" is very largely the cultivating of latent powers of this order ; the psychological difference between a Hottentot and an ambassador is the high development of the powers of inhibition acquired by the latter. Training in children and animals means their acquiring inhibitory powers : a performing tiger has to restrain many instincts and

tendencies before it can be conveniently exhibited in public. Now some forms of nervousness are the result of loss of inhibition manifested in the expression of violent emotions and violent responses of all sorts.

The strong man is not the violent man; the strong man is the man who restrains the exhibitions of his strength, who strongly controls strong emotions for his own good and that of the community. The neurotic person, not possessing the necessary power of inhibition, does not do this. Better is "he that ruleth his spirit than he that taketh a city"; that was written long ago, but the nervous system was the same then as now; in modern language it is inhibition that is alluded to. Nervousness may, then, in one form be a condition of diminished restraint. We talk about a nervous dog that barks apprehensively at every little incident, of a nervous horse that jibs and shies at all sorts of harmless objects; inhibition is that in which these animals are deficient. It is, then, clear that the development of inhibition is the

essence of foundation of character: a person with little inhibition may do all sorts of wild things, succumb to all sorts of temptations: conscious inhibition is the physiological name for self-control.

Lack of inhibition is one of the elements in neurasthenia, that low nervous state to which reference has already been made. Hysteria, again, is a form of nervousness; it is a morbid state of the central nervous system, and has been described as the acting or imitating of some other disease. "A fit of hysterics" is really a violent emotional display due to diminished inhibition. In true hysteria all sorts of morbid conditions are imitated—fainting, paralyses of various kinds, and so on. Some hysterical people cannot walk, cannot talk, cannot eat, cannot get out of bed, and so forth. Hysteria is a form of "nervousness," if "nervousness" means anything unusual in the nervous system, which is apparently all that in certain cases it does mean. The term as popularly used covers a large number of very different conditions. By a nervous child is meant

sometimes a shy child, one not sufficiently self-reliant, who shrinks from strangers, and is not soon at home amid new surroundings. It may only mean a child that does not like to be left alone in the dark.

A very well marked form of nervousness is the "fear" of various conditions, such as fear of looking over heights, fear of open spaces, fear of enclosed spaces, fear of the presence of crowds, and so on through all the various "phobias," as they are called, many of which are ludicrous to those incapable of experiencing them. Allied to hysterias and phobias are certain harmless obsessions which, however, lead right on to the illusions, delusions, and hallucinations of typical mania.

In connexion with nervousness we have the factor of *suddenness* to reckon with. Something happening without warning will *un*nerve a man or animal which it would not do had the occurrence been foretold or developed gradually. Just as a sudden knock will break a glass which the same pressure cautiously applied would not, so

a sudden mental blow will injuriously affect the nervous system in a way it would not have done had it fallen more gradually. Both non-living and living molecules resent sudden changes of state; both can endure strains if gradually applied which would not be withstood if applied without warning. Especially should the affectable and plastic nervous systems of children be protected from sudden impacts. Permanent damage may be done them by "taking them by surprise," "giving them frights," suddenly showing them "horrors," and so forth. The nervous system will "endure" (almost) "all things" provided they are presented to it in graded order: it may be trained by degrees to suffer conditions which if suddenly developed would have overwhelmed it altogether.

CHAPTER VIII

SCIENCE AND FAITH-HEALING

In the last preceding chapter we saw something of the way in which the body works as a whole and in its several parts by means of nerves; in this last chapter we shall consider more particularly the influence of the mind on this same nervous mechanism.

The purely materialistic view of life is incomplete. To ignore consciousness, the mind, the non-material in the individual, is philosophically absurd. Consciousness as a real existence, and its influence on the body and on other minds, must be reckoned with in any analysis of life more serious than that we might expect to hear from some ephemeral orator in Hyde Park. So too it is highly unphilosophical to ignore consciousness as a cause, merely because we do not at the present moment

understand how it arises and how it disappears. A man in his waking state is, indeed, not anatomically different from a man in deep sleep or under the influence of chloroform, but physiologically the differences are important and are directly related to the absence of consciousness in the latter conditions.

The fact is, we rise to no adequate conception of the characteristics of vitality until we regard the body and the mind as one organism, a single functional unit with two aspects, one towards the material and the other towards the *supra*-material order of existence. The individual, the person, is more than the body and more than the mind at one and the same moment. He is the resultant of two mutually dependent and mutually reactive orders of existence, for which complex there is no single term in common use. "Mind-body" expresses the notion, although psycho-some might serve as a more technical term. We are told that Plato was originally responsible for the extreme dualism of the popular belief.

One of the most remarkable by-products of the Great War has been the recognition on the part not only of professional psychologists but of ordinary medical practitioners of the doctrine of mind or consciousness *as a cause.* "Psychogenesis," "psychotherapeutics" were indeed terms used before the date of that great conflict, but they were used in the fullness of their meaning by only a few writers on matters mental who wished to express the idea that the mind was responsible for some bodily state in a manner we knew not how. The day is not so very long past when "interactionists" were regarded with disfavour and even pity by metaphysicians and "pure" psychologists. Some of us who proclaimed that consciousness could be the cause of a material condition as truly as any material antecedent could be, and who believed in the reality of nerve-energy, were considered to be intellectually not quite respectable, and to be lost in the outer darkness of the unthinkable. But the hospitals during the war soon became crowded with men whose troubles were

evidently largely mental and whose cures were entirely so. Materialistic physicians began crediting emotions with all sorts of curative powers, and began using hypnotic suggestion for curative purposes with a success as astonishing to themselves as to their patients. Before the end of the war medical men began publishing their gratifying results in books in which interactionism was acknowledged as of the essence of the treatise. A special journal —*Psyche*—devoted to non-material things is now regularly advertised in the pages of *Nature*, which also reports the transactions of the Metaphysical Society.

The view of the ordinary person that mind influences body, and body mind, is so obvious and familiar that some of my readers may not have realized that a causal bond between the two was ever questioned. That we cannot at present explain *how* the interaction comes about, must not prevent our recognizing the fact as a natural phenomenon. It is a commonplace of popular admission that a hungry man is an angry man; and it is futile to

deny that it is the state of depletion of certain of his bodily tissues which is the direct causal antecedent of his experiencing the disagreeable emotion just alluded to. It is not without physiological and psychological sanction that it is towards the end of the feast that the subscription list for the charity is sent round for signature. The sea-sick person hails even drowning as a way out of his misery. The point is much too familiar to be laboured further; we know very well how bodily conditions can reverberate in the mind and arouse more particularly the affective aspects of it.

Pain itself is but the conscious correlate of a tissue condition which has overstepped in intensity the elastic limits of the normal. In this aspect pain is "subjective," mental, in the sense that it is a modification—a disagreeable one—of the consciousness or psyche. You crush your foot, you say your foot hurts you. The consciousness of your foot has become so obtrusively, disagreeably modified that it receives the special name of "pain"; and that pain

is in the mind and of the mind as truly as is our recollection of yesterday or our hope of to-morrow. But this is by no means all. Pain is not experienced save in connexion with a disturbance in an inconceivably complicated organ of the central nervous system called the brain. The brain must co-operate as an underlying material substratum before pain can arise in consciousness. No cerebrum, no pain. Thus the sympathy that certain people bestow on brainless oysters and lobsters about to be cooked is almost certainly wasted.

Pain is the conscious correlative of an unduly excited condition in the brain in consequence of too violent nerve-impulses having ascended from some tissues of the body physically or chemically insulted. The pain is in the foot, in the nerves, in the brain, and in the mind all at the same time. But it is not in the foot unless the nerves are intact. If, as arising from some congenital or accidental condition, the nerves of pain in the spinal cord are not conducting, then a person may lift up a

hot coal and feel no pain. In leprosy, where the nerves are destroyed, it is impossible to induce pain in the fingers or toes. Cases of this kind were met with during the war. Not many hundred years ago such a person would have been persecuted as a wizard in league with the devil. But he would have been capable of doing a miracle, for no ordinary person can handle red-hot coals and not be painfully scorched. Cases are known where from disease in the centre for vision in the brain there is blindness although the eyes and optic nerves are quite intact; and conversely, with eyes shut in sleep we may nevertheless see gorgeous visions because the centre for vision is awake.

Pain cannot be in the foot and not also in the brain, but it can be in the brain and not also in the foot. Pain is not in the nerves or in the brain unless the person is conscious, and yet it can be in the brain and in the mind long after the foot may have been amputated. This is the well-known "hallucination of the absent member." Long after limbs have been removed,

men have imagined not only their presence but their *painful* presence. Severe pain produces a disturbance throughout the whole psycho-some expressed on the material side by demonstrable, microscopic changes in certain cells of the brain, expressed on the conscious side by the extreme fatigue which prolonged pain induces. The most materialistic of surgeons now recognize that the patient's fear and his distress before operation put him into a physical condition in which he is much less able to withstand the operation than if precautions have been taken to minimize or ward off that fear.

But this by no means exhausts our analysis of pain. We have just seen that pain may be hallucinatory; we have now to learn that pain may also be illusory. One of the things most familiar to those who have to examine patients complaining of pain is the existence of pain over certain regions of the body which have apparently nothing to do with the internal organ which is believed to be in discomfort or disease. Certain sufferers know that in liver disease there is pain behind the right shoulder

blade, in heart disease pain shoots into the left arm, in severe indigestion there may be pain not only over the breast-bone, but in the head (frontal or ocular headache). These so-called "sympathetic" or referred pains can be explained by assuming that the irritation in the nerve from the internal organ has somewhere and somehow become transferred to the nerve from the skin-area in question, with the result that the mind believes the latter to be the seat of pain when that skin-area is not the seat of any painful condition on its own account. Psychologically it is an illusion; pain is believed to be where there is no lesion, no pain-producing state. Technically described, it is an algesic illusion; consciousness has made a mistake in referring the pain to the skin when the disease is in an internal organ. The pain is real, it is mental, but it is referred to an unoffending part of the body, and to that extent there is illusion about the source of the pain.

I draw attention to this condition to show that while pain may be reported as

distinctly felt in a certain part of the body, it does not necessarily follow that in that same district lies the seat of the disease. Disease may be in one place, its referred pain in another, and it would be possible to remove the referred pain without removing the disease responsible for it. If the most distressing thing for the patient be the referred pain and not the inward, hidden cause of the disease, then the removal of the referred pain might be accepted by the inexpert or uncritical as a cure of the disease itself. There is no doubt that certain present-day "miraculous" cures belong to this class.

There is one more feature of sensation and pain which requires to be kept in mind in connexion with their mental aspects, the feature that physiologists call "after-sensations." A sensation does not subside the moment its stimulus has ceased to act; a pain often persists after the morbid condition has been removed. Most physicians know that there is a tendency in the bodily organs to continue to act in the abnormal or depraved manner even

although the source of their previous derangement has been successfully treated; a morbid habit, in other words, has been established, and as such tends to persist. The persistence of pain is to be included among the possible after-sensations. These post-stimulant pains are of the nature of illusions in that they are in the mind when now there is no objective morbid state to account for them. They are retained in consciousness by a sort of psychic momentum. It is not difficult to see how a cure by so-called "faith-healing" might be claimed through the removal of an illusory pain, the actual lesion for which was at the time non-existent.

When now we turn our attention to the other correlation, that of mind over body, we encounter something of the highest importance for the subject of truth about faith-healing. That mind can influence body is again so elementary a conception that a child in the nursery would give assent to it as soon as he had grasped the meaning of the words employed. The

mind plays on the body with a facility comparable only to that of some expert musician playing on the organ. By our will we have control over many scores of muscles designed for the execution of a large number of movements of bones around joints. It is on this account that these muscles are called "voluntary." Psycho-physiologists know, however, that the emotional aspects of the mind are capable of much more varied expression in the activities of the bodily organs than is the will itself. If the will is a musician fingering the keys of one instrument, the emotions are a whole orchestra playing on a representative of every instrument yet invented.

Emotional expression is multiform; blood-vessels may dilate or contract in blushing or blanching; glands may secrete or be dried up in pleasurable excitement or in devitalizing terror. The heart may be hastened or slowed in rate, may be increased in force, weakened or brought altogether to a standstill through the influence of emotion alone. So universally

is this recognized, that the word "heart" has come to be a synonym for emotion. Very few of the other internal organs are exempt from this emotional influence or interference. The emotion, too, may combine with the will in intensifying its power over the voluntary muscles, as when the fragile woman, to save her child from the burning building, can perform feats of muscular power absolutely beyond her every-day, calm state of mind.

More than that, emotion can achieve what is impossible to the will. The will is powerless to flush or blanch the cheek, the will can call forth no digestive juices, but excitement can increase or diminish their quantity. It is the mother's agitation of mind, and not her intention, that can alter the quality of the milk so that it becomes actually poisonous for the infant. Emotion is the great, causal, mental state, mightier than the will, outside its control, beyond it and above it.

Within the last few years physiologists have perfected an electrical method, for demonstrating objectively the existence of

emotion as distinguished from volition or from a purely intellectual state of active thought. A particularly interesting feature of the method is, that while the instrument is plainly influenced by emotional states, and quite evidently by the primitive emotions of displeasure or anger, it is left absolutely unaffected by simulated emotion as in acting a part or reciting a poem, no matter how "emotional" the characterization may appear. The instrument gives a large response when a pin prick is either actually given or only threatened; whereas when the person experimented on declaims the most "rousing" speech, the emotions of which he does not experience, the instrument makes no response whatever.

It does not take much knowledge of medicine to appreciate the potential value of an objective method that will distinguish between the emotional and the non-emotional states of mind, and which will also actually discriminate between the depressing emotion of real grief and the fictitious emotions of the hysterical and the malingerer. A good many "faith cures" have

been in persons whose illness was due to feigned emotion.

Now, what is " faith " but the emotional aspect of religious consciousness? If religion is the highest aspiring of the human consciousness, then faith is its omnipotent, emotional aspect. The will can do much, emotion can do more, but faith can "remove mountains"—mountains of physical disease and of mental disease, of misery and of suffering. And " faith can subdue kingdoms," the kingdoms of the rule of everything that is unlovely, such as indifference to the welfare of others, self-seeking at the expense of others, and self-righteousness with the condemnation of others.

The omnipotence of mind in that dual organism, the individual, is then abundantly manifest. But mind can not only influence the body, it can create conditions within itself. The mind has forces *per se*; emotion is the supreme creative activity in the realm of mind. This mental creation is learnedly called an "hallucination," a sensory perception based on no external,

objective stimulation of the organs of sense—"a dagger of the mind," as Shakespeare has it:

> Art thou not, fatal vision, sensible
> To feeling as to sight? or art thou but
> A dagger of the mind; a false creation
> Proceeding from the heat-oppressèd brain?

This power of mental creation is of the utmost consequence when the influence of the psyche is considered. By it the mind can, on the one hand, create its own state of insensibility to existing pain, and on the other can institute a condition of well-being even when the body is in the throes of a malignant disease. The mind is in this sense *all*—all-powerful. There is nothing physically good or bad, but thinking makes it so.

The mind can either exalt or reduce the bodily resistance to disease. We have definite chemical and physical objective proofs of increased and diminished tissue-changes produced by a cheerful and by a depressed state of mind respectively. It is this aspect of pain and suffering which the so-

called "Christian Scientists" have emphasized. Their contention that pain is mental is true; that it is *wholly* mental is not true. We find no warrant in Scripture for their assertion that all pain is an expression of moral evil and would not exist were evil not present The Book of Job seems to indicate quite the contrary.

It is in the condition of the hypnotic trance that hallucinations are most surely produced, and are most potent for the amelioration of disease. Let me quote a paragraph from a paper in *Brain*, by one of the most critical professional hypnotists in London, Dr. J. Milne Bramwell:

"He" (the hypnotized person) "has acquired a control over his own mind and body without parallel in waking life. He can alter the rhythm of his pulse, control his secretions and excretions, and increase or arrest the activity of his special senses. He can induce anæsthesia and analgesia, and yet maintain consciousness and volition unimpaired. From the therapeutic side he can obtain relief from the pain of disease or injury, procure sleep at will and for as

long or short a time as he wishes. He can escape from obsessions, conquer the diseased craving for alcohol and narcotics, and get rid of numerous functional nervous disturbances. All these phenomena cannot be evoked in every case, but something can always be effected beyond the power of the waking will."

Relief or cure, it is asserted, has been obtained by hypnotic treatment in the following diseases: Painful affections of muscles and joints persisting after injury, curvature of the spine, heart-disease, and dropsy, certain paralyses, certain skin diseases, certain dyspepsias and their attendant irregularities, certain forms of deafness, epilepsy, neuralgia, and headache; various forms of muscular spasm such as chorea, hysterical paralysis, and aphasia. Such mental conditions as somnambulism, catalepsy, monomania, and delirium tremens have similarly been ameliorated or cured. Scores of medical men tell us how during the war they saw, for the first time, suggestion or mental healing employed instead of drugs or the knife. It was indeed a sudden

conversion for some of these materialistic physiologists to find that their purely materialistic theories of life had been weighed in the balances of a therapeutic emergency and found wanting. Many a man who had ignored consciousness as a cause had unexpectedly to admit that the greatest thing in man was mind. It was certainly a strange result of that Armageddon which seemed to enthrone brute force and physical suffering amid an outraged humanity, to discover the beneficent action of mind over the ills of the body so abundantly demonstrated.

The astonishing possibilities of hypnotism, whether called by the names of hetero- or auto-suggestion, mental therapy, or mesmerism, are known only to comparatively few medical men owing to the obloquy under which for so long a time the practice of this art has remained in English-speaking countries. France used it early in scientific treatment. Mesmer (1734–1815), who discovered the power of mental suggestion, soon became a conscious deceiver of the public. " Mesmerism

—hypnotism—soon became so overlaid with quackery and credulity that its practice in England was early abandoned almost entirely to unscrupulous charlatans. Possibly no curative agency has been so abused; possibly none is capable of so much abuse. Its practice for purposes of mere entertainment had to be forbidden in England some thirty years ago. Hypnotism is not a plaything, it is a great reality. But hypnotism, except in name, is no discovery of this present age. It is as old as the use of magic itself, as old as the human race. The mysterious incantations, the dimmed lights, the monotonous lowered voices were all accessories to the priestly practice of what we should nowadays simply call "suggestion."

In the hypnotic state, what is believed forthwith exists. You tell your patient he will become cold, and in due time he shivers; that he will become hot, and in due time he perspires. You tell him that quinine is sweet and he drinks it with avidity, you tell him that sugar is bitter and he forthwith rejects it. There seems

to be no limit to these mental creations; but it is his *own* belief that you are using, his *own* faith that is operative. The mind finds what the mind brings. I admit I am not using the word "faith" for the moment in the exclusive sense of the highest form of religious emotion; but what I want to emphasize is, that the belief in the powers of one's own mind as a curative agency—auto-suggestion—is a thing of the same therapeutic order as that morally receptive attitude designated by Christians as "faith."

It is an impossible task to establish the historical truth of every case of so-called "faith-healing," or to explain by what agency even those verified cases of cure have been accomplished. For such a task I am in no way qualified, being versed neither in Theology nor in Ecclesiastical History. I merely wish to indicate the scientific principles on which the amelioration or cure of a certain number of diseases can be accounted for.

There is no better definition of "suggestibility" than that given by Professor

McDougall, formerly of Oxford University, now of Harvard. He defines it as a "process of communication resulting in the acceptance with conviction of the communicated proposition in the absence of logically adequate grounds for its acceptance."

I confess it seems to me that this definition is by no means far away from a definition of "faith" itself—"believing where we cannot prove." For psycho-therapeutic purposes, conviction or belief is half the battle: "faith is the substance of things hoped for"; and this attitude of mind is the opposite of that which waits on proof. There is so much that is unknown and possibly unknowable in the interactions of psyche and soma that faith is the only possible attitude, faith not indifference, faith not a hopeless agnosticism, the faith of which Jesus is the "author and finisher." Many a time it has been demonstrated that he will get well who believes he will. Auto-suggestion is of amazing therapeutic import.

It has been truly remarked that the

diseases specially recorded both in the New Testament and in the earlier ages of the Church's history as being cured by an act of faith were just those which a physician of the present day would call "functional." By "functional" is meant not the result of anatomical injury or demonstrable gross lesion. No amount of faith will remove a cancer or make the two bits of a broken bone come together at a rate faster than is determined for them by the *vis medicatrix naturæ*; but the attitude of the patient's mind can exert a good or a bad influence—particularly through the blood supply—on the condition of those tissues which are contributing to the union.

It must not be forgotten that the unconscious mind is at times quite as potent as the conscious in bringing about curative results. Indeed, the resemblances between the unconscious mind and the emotions themselves are in this direction exceedingly close. Under strong emotion the person can become oblivious of his surroundings —"beside himself" with rage, transported with joy, and so forth, until we say he is

"another being." Now a subconscious influence may work unsuspected, perhaps for a long time, either for good or evil in an individual until his character has become definitely moulded, and his personality determined in some particular direction. Unconscious influences for good in the realm of the physical organism are now firmly believed in, and, as auto-suggestion, should be included under the expression "faith-healing."

It has often been remarked in certain instances of faith-healing on the part of Our Lord, that He used the co-operation of the sick person's faith itself. This is notably so in the case of the woman in the viiith chapter of Luke's Gospel, to whom Christ said—"Daughter, be of good comfort, thy faith hath made thee whole," and this, although it is also recorded that "Jesus perceived that virtue had gone out of Him." A similar case is to be found in the xviith chapter of Luke's Gospel, where the leper, the stranger, on being cured returned to give thanks, to whom Christ said—"Arise, go thy way, thy faith hath made thee whole."

In judging of the diseases of which people were cured in New Testament times, we have to remember that their exact nature is not necessarily revealed by the names given to them in our translation of the Bible. It is not to be expected that the terminology of diseases in use in the first and second centuries should be at all consonant with the names we give these diseases at the present day. Obviously the names were intelligible to those for whom the Gospels and Epistles were originally written. For instance "leprosy" in ancient times may have meant something different from what a modern pathologist means by the oriental disease of the nervous system due to a bacillus, the *bacillus lepræ*.

Another notable feature of the faith-healing in New Testament times is what one may call "curative action at a distance." Such a case is that of the leper in Luke xvii, for while he was on his way to the priest the cure came. Other cases of cure at a distance are: the curing of the child of the Syro-Phœnician woman

(Matt. xv) to whose mother Christ said, "O woman, great is thy faith"; the servant of the centurion (Matt. viii) to whose master Christ said: "I have not found so great faith, no, not in Israel"; and the son of the nobleman alluded to in the Gospel of John, chapter iv, to whose father Christ said, "Go thy way, thy son liveth."

It is well known that under the influence of hypnotism a patient can be *en rapport* with the hypnotist to such an extent that after hours or days of absence something that the latter has suggested being done or not being done will be done or not respectively. This, clearly, is not so much action at a distance, as action after a certain interval of time; it is, no doubt, what is meant by "telepathic," although either "telæsthetic" or "tele-inductive" would be a better term. Evidently, if action is being induced in another mind as a post-hypnotic suggestion, space as space does not enter into the process as a deterring condition at all. Space in fact is being rapidly annihilated, as is shown in

the latest triumph of science, wireless telephony. Consider the transformation involved in the following series:

One person thinks, nerve-impulses descend to the muscles of his tongue, palate, lips, etc., and he speaks his thoughts, the sound-waves travel through the air, and, falling on a telephone receiver, are through magnetic means transmuted into electrical waves which travel without wires it may be for thousands of miles through the invisible æther.

When they arrive at a receiving station (whose instrument is in tune with the transmitting one), the ætherial waves become instrumental electrical waves, which through magnetic means are converted back into the sounds of words that arouse ideas in the mind of a second person. Thus A's thoughts have induced afar corresponding thoughts in B's mind. If, now, the thoughts of A were of therapeutic value for B, and B was in hypnotic rapport with A, B could quite conceivably be the subject of a veritable cure at a distance. This is tele-psycho-therapeutics, and there

is no theoretical limit to the intervening distance. Sir Oliver Lodge has hinted that it might extend to other worlds. To talk to your friends and to be replied to without any material bond whatever would have been magic, the blackest of black art, in an earlier age. Men and women were burned for much less. Only a few years ago, wireless telephony itself would have been pronounced impossible because inconceivable; but the inconceivable of the last generation is the attainable of the present, and the commonplace of the next.

At this moment the potentialities of the human mind are only being vaguely hinted at. The rôle assumed by the subconscious mind—the subliminal ego revealed as auto-suggestion in psycho-analysis—the results which flow from the partition of consciousness and from the simultaneous or alternating states of a duplicate or multiple personality, the recognition of the reality of nerve-energy and of therapeutic telepathy are nowadays part of the accepted order of things. So too the

restoring of the body to health by mental means may some day be regarded as the very least of the achievements of the human spirit: space has already been overcome, the conquest of the dark kingdom of disease is even now in progress. We are a very long way from knowing as we are known, and "it doth not yet appear what we shall be, but we know that when He shall appear we shall be like Him, for we shall see Him as He is."

Inasmuch as disease is disharmony in animate Nature, it is our duty to banish it; and in so doing we shall but be treading in the footsteps of the Great Physician. But to what end is this continual striving to abolish pain, and that pain often the result of our own misdeeds? The desire to abolish personal suffering is, no doubt, perfectly natural. But, I ask, shall we lay the foundations of our religion on no higher aspiration? Shall we bind ourselves together on no basis of belief or faith more worthy than this, that we desire to escape from pain and to banish disease?

How can this be the object of the exercise

of our most fervent faith? Where in *this* religion would be the place for worship? Do we not seem to hear the apostle's warning?—"And though I have *all faith*, so that I could remove mountains, and have not charity, I am nothing."

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